



US009236418B2

(12) **United States Patent**  
**Yamazaki et al.**

(10) **Patent No.:** **US 9,236,418 B2**  
(45) **Date of Patent:** **Jan. 12, 2016**

(54) **LIGHT EMITTING DEVICE**

*51/5253* (2013.01); *H01L 27/322* (2013.01);  
*H01L 27/3211* (2013.01); *H01L 51/5228*  
(2013.01); *H01L 51/5234* (2013.01); *H01L*  
*51/5281* (2013.01)

(71) Applicant: **Semiconductor Energy Laboratory**  
**Co., Ltd.**, Kanagawa-ken (JP)

(72) Inventors: **Shunpei Yamazaki**, Tokyo (JP);  
**Masaaki Hiroki**, Kanagawa (JP);  
**Masakazu Murakami**, Kanagawa (JP);  
**Hideaki Kuwabara**, Kanagawa (JP)

(58) **Field of Classification Search**

CPC . *H01L 27/32*; *H01L 27/3206*; *H01L 27/3211*;  
*H01L 27/3216*; *H01L 51/5012*; *H01L*  
*51/5036*; *H01L 51/504*; *H01L 51/5044*  
See application file for complete search history.

(73) Assignee: **Semiconductor Energy Laboratory**  
**Co., Ltd.** (JP)

(56)

**References Cited**

U.S. PATENT DOCUMENTS

(\*) Notice: Subject to any disclaimer, the term of this  
patent is extended or adjusted under 35  
U.S.C. 154(b) by 0 days.

4,871,236 A 10/1989 Gemma et al.  
4,971,919 A 11/1990 Yamazaki

(Continued)

(21) Appl. No.: **14/153,362**

(22) Filed: **Jan. 13, 2014**

(65) **Prior Publication Data**

US 2014/0124771 A1 May 8, 2014

FOREIGN PATENT DOCUMENTS

EP 0 940 797 A1 9/1999  
EP 0 989 778 A1 3/2000

(Continued)

**Related U.S. Application Data**

(60) Continuation of application No. 11/476,508, filed on  
Jun. 28, 2006, now Pat. No. 8,629,439, which is a  
division of application No. 10/349,750, filed on Jan.  
22, 2003, now Pat. No. 7,098,069.

Primary Examiner — Jesse Y Miyoshi

(74) Attorney, Agent, or Firm — Husch Blackwell LLP

(30) **Foreign Application Priority Data**

Jan. 24, 2002 (JP) ..... 2002-016244

(51) **Int. Cl.**

*H01L 27/14* (2006.01)  
*H01L 29/04* (2006.01)  
*H01L 27/32* (2006.01)  
*H01L 51/52* (2006.01)

(52) **U.S. Cl.**

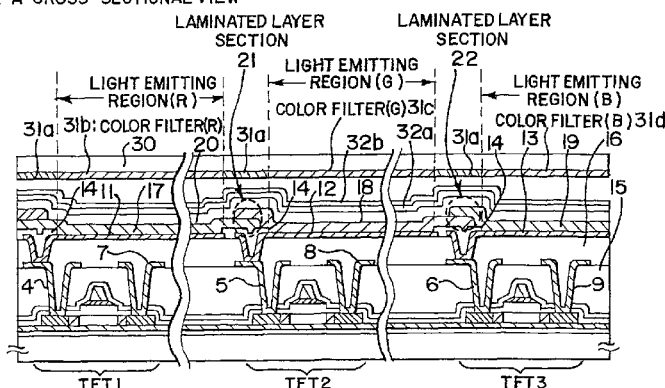
CPC ..... *H01L 27/32* (2013.01); *H01L 27/3246*  
(2013.01); *H01L 27/3258* (2013.01); *H01L*

**ABSTRACT**

A light emitting device having a high definition, a high aperture ratio and a high reliability is provided. The present invention realizes a high definition and a high aperture ratio for a flat panel display of full colors using luminescent colors of red, green and blue without being dependent upon the film formation method and deposition precision of an organic compound layer by forming the laminated sections **21**, **22** by means of intentionally and partially overlapping different organic compound layers of adjacent light emitting elements. Moreover, the protective film **32a** containing hydrogen is formed and the drawback in the organic compound layer is terminated with hydrogen, thereby realizing the enhancement of the brightness and the reliability.

**21 Claims, 14 Drawing Sheets**

A-A' CROSS-SECTIONAL VIEW



(56)

## References Cited

## U.S. PATENT DOCUMENTS

5,478,777	A	12/1995	Yamazaki	7,468,285	B2	12/2008	Yamazaki et al.
5,677,546	A	10/1997	Yu	7,473,928	B1	1/2009	Yamazaki et al.
5,682,043	A	10/1997	Pei et al.	7,518,146	B2	4/2009	Yamazaki et al.
5,920,080	A	7/1999	Jones	7,579,203	B2	8/2009	Yamazaki et al.
5,929,474	A	7/1999	Huang et al.	7,592,652	B2	9/2009	Kimura
5,970,318	A	10/1999	Choi et al.	7,732,824	B2	6/2010	Konuma et al.
6,013,384	A	1/2000	Kido et al.	7,932,518	B2	4/2011	Seki et al.
6,066,518	A	5/2000	Yamazaki	7,952,103	B2	5/2011	Yamazaki et al.
6,107,734	A	8/2000	Tanaka et al.	8,158,992	B2	4/2012	Konuma et al.
6,198,091	B1	3/2001	Forrest et al.	8,159,124	B2	4/2012	Yudasaka
6,198,092	B1	3/2001	Bulovic et al.	8,183,571	B2	5/2012	Yamazaki et al.
6,208,077	B1	3/2001	Hung	8,450,745	B2	5/2013	Yamazaki et al.
6,278,055	B1	8/2001	Forrest et al.	2001/0031509	A1	10/2001	Yamazaki
6,288,486	B1	9/2001	Tsuruoka et al.	2001/0043043	A1	11/2001	Aoyama et al.
6,297,495	B1	10/2001	Bulovic et al.	2001/0043046	A1	11/2001	Fukunaga
6,352,777	B1	3/2002	Bulovic et al.	2001/0046611	A1	11/2001	Kido et al.
6,366,016	B1	4/2002	Sakaguchi et al.	2001/0053559	A1	12/2001	Nagao et al.
6,366,025	B1 *	4/2002	Yamada ..... 315/169.3	2002/0021268	A1	2/2002	Yamazaki et al.
6,380,672	B1	4/2002	Yudasaka	2002/0057055	A1	5/2002	Yamazaki et al.
6,392,340	B2	5/2002	Yoneda et al.	2002/0079512	A1	6/2002	Yamazaki et al.
6,420,834	B2	7/2002	Yamazaki et al.	2002/0119297	A1	8/2002	Forrest et al.
6,423,429	B2	7/2002	Kido et al.	2002/0125817	A1	9/2002	Yamazaki et al.
6,429,584	B2	8/2002	Kubota	2002/0158835	A1	10/2002	Kobayashi et al.
6,445,005	B1	9/2002	Yamazaki et al.	2002/0189666	A1	12/2002	Forrest et al.
6,451,415	B1	9/2002	Forrest et al.	2002/0197462	A1	12/2002	Forrest et al.
6,452,092	B2	9/2002	Han et al.	2003/0042846	A1	3/2003	Forrest et al.
6,475,845	B2	11/2002	Kimura	2003/0089913	A1	5/2003	Takayama et al.
6,479,838	B2	11/2002	Morosawa	2003/0122140	A1	7/2003	Yamazaki et al.
6,489,176	B2	12/2002	Ninomiya	2003/0137325	A1	7/2003	Yamazaki et al.
6,489,631	B2	12/2002	Young et al.	2003/0155573	A1	8/2003	Yamazaki et al.
6,524,884	B1	2/2003	Kim et al.	2003/0209974	A1	11/2003	Yamazaki
6,567,146	B2	5/2003	Hirakata et al.	2003/0218166	A1	11/2003	Tsutsui
6,580,213	B2	6/2003	Yamazaki	2003/0219928	A1	11/2003	Kato et al.
6,580,214	B2	6/2003	Yoneda et al.	2004/0003939	A1	1/2004	Nishi et al.
6,593,691	B2	7/2003	Nishi et al.	2004/0027059	A1	2/2004	Tsutsui
6,605,826	B2	8/2003	Yamazaki et al.	2004/0027061	A1	2/2004	Seo et al.
6,614,174	B1	9/2003	Urabe et al.	2004/0113546	A1	6/2004	Forrest et al.
6,641,933	B1	11/2003	Yamazaki et al.	2004/0151887	A1	8/2004	Forrest et al.
6,642,651	B2	11/2003	Yudasaka	2005/0012105	A1	1/2005	Yamazaki et al.
6,656,519	B2	12/2003	Sakaguchi et al.	2005/0012445	A1	1/2005	Yamazaki et al.
6,689,492	B1	2/2004	Yamazaki et al.	2005/0045917	A1	3/2005	Yamazaki et al.
6,692,820	B2	2/2004	Forrest et al.	2006/0180826	A1	8/2006	Yamazaki et al.
6,720,198	B2	4/2004	Yamagata et al.	2007/0007870	A1	1/2007	Yamazaki et al.
6,768,259	B2	7/2004	Hirano	2007/0082430	A1	4/2007	Yamazaki
6,781,152	B2	8/2004	Yamazaki	2009/0298210	A1	12/2009	Yamazaki et al.
6,781,162	B2	8/2004	Yamazaki et al.	2009/0315066	A1	12/2009	Kimura
6,812,637	B2	11/2004	Cok et al.	2012/0199853	A1	8/2012	Konuma et al.
6,815,723	B2	11/2004	Yamazaki et al.	2013/0313558	A1	11/2013	Yamazaki et al.
6,828,727	B2	12/2004	Yamazaki				
6,833,560	B2	12/2004	Konuma et al.				
6,844,025	B2	1/2005	Forrest et al.				
6,849,877	B2	2/2005	Yamazaki et al.				
6,864,629	B2	3/2005	Miyaguchi et al.				
6,867,430	B2	3/2005	Kato et al.				
6,882,102	B2	4/2005	Yamazaki				
6,885,148	B2	4/2005	Yudasaka				
6,894,312	B2	5/2005	Yamazaki et al.				
6,936,485	B2	8/2005	Yamazaki et al.				
6,958,489	B2	10/2005	Kimura				
6,969,291	B2	11/2005	Urabe et al.				
7,012,290	B2	3/2006	Kimura				
7,015,503	B2	3/2006	Seki et al.				
7,112,374	B2	9/2006	Yamazaki et al.				
7,113,154	B1	9/2006	Inukai				
7,119,364	B2	10/2006	Yamazaki				
7,129,102	B2	10/2006	Yamazaki				
7,132,693	B2	11/2006	Konuma et al.				
7,214,959	B2	5/2007	Seki et al.				
7,268,851	B2	9/2007	Hirakata et al.				
7,273,801	B2	9/2007	Seki et al.				
7,283,185	B2	10/2007	Hirakata et al.				
7,364,939	B2	4/2008	Yudasaka				
7,411,211	B1	8/2008	Yamazaki				
7,420,208	B2	9/2008	Yamazaki et al.				
7,442,955	B2	10/2008	Seki et al.				

## FOREIGN PATENT DOCUMENTS

EP	1 026 757	A2	8/2000
EP	1 085 576	A2	3/2001
EP	1 087 448	A2	3/2001
EP	1 093 166	A2	4/2001
EP	1 102 317	A2	5/2001
EP	1 103 946	A2	5/2001
EP	1 122 794	A2	8/2001
EP	1 128 436	A1	8/2001
EP	1 139 454	A2	10/2001
EP	1 376 713	A2	1/2004
EP	1 505 648	A2	2/2005
EP	1 793 650	A2	6/2007
EP	2 259 322	A2	12/2010
JP	5-101886		4/1993
JP	5-108014		4/1993
JP	10-189252		7/1998
JP	11-67454		3/1999
JP	11-214157		8/1999
JP	11-251059		9/1999
JP	2000-91082		3/2000
JP	2000-123975		4/2000
JP	2000-150171		5/2000
JP	2000-195677		7/2000
JP	2000-208253		7/2000
JP	2000-223264		8/2000
JP	2000-353594		12/2000
JP	2000-357584	A	12/2000
JP	2001-148291		5/2001

(56)

**References Cited**

FOREIGN PATENT DOCUMENTS

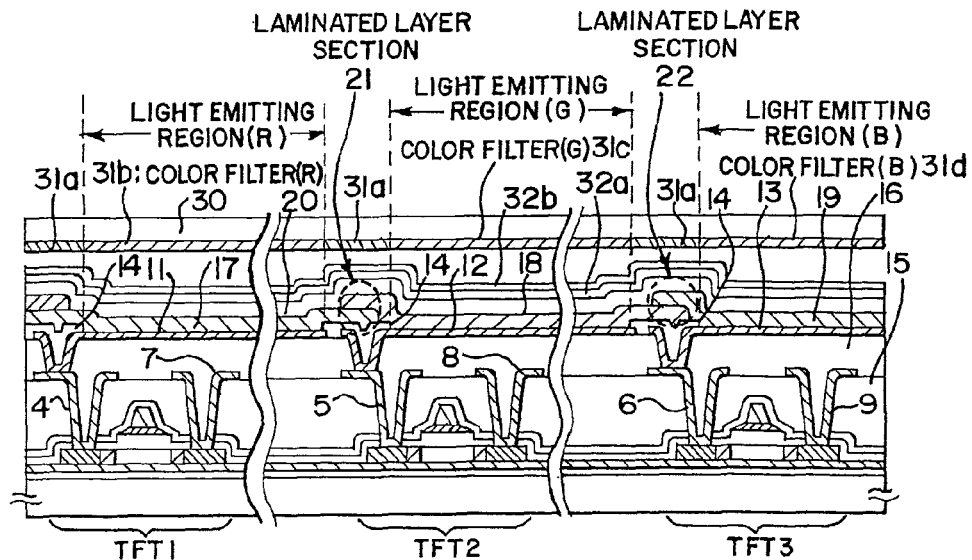
JP	2001-189192	7/2001
JP	2001-196174	7/2001
JP	2001-214159	8/2001
JP	2001-217072 A	8/2001
JP	2001-284041	10/2001
JP	2001-290439	10/2001
JP	2001-312223	11/2001
JP	2001-319776 A	11/2001

JP	2001-319789	11/2001
JP	2001-343911	12/2001
JP	2001-343933	12/2001
JP	2001-345180	12/2001
JP	2001-356711 A	12/2001
JP	2002-15861	1/2002
JP	2002-508108	3/2002
JP	2003-197371	7/2003
WO	WO 98/59528 A1	12/1998
WO	WO 99/10862 A1	3/1999

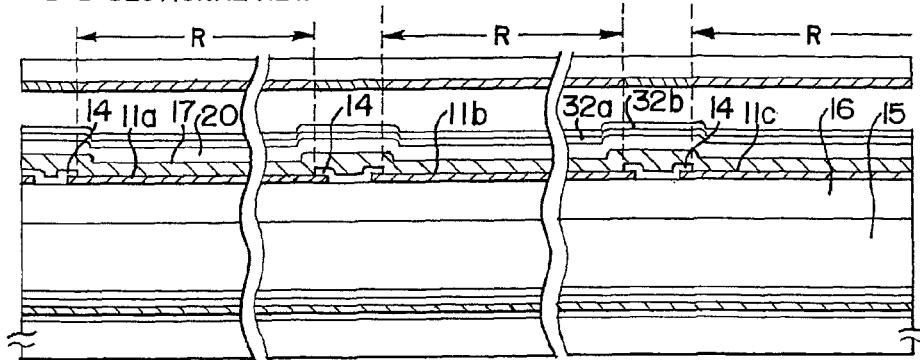
\* cited by examiner

**FIG.1A**

A-A' CROSS-SECTIONAL VIEW

**FIG.1B**

B-B' SECTIONAL VIEW

**FIG.1C**

C-C' SECTIONAL VIEW

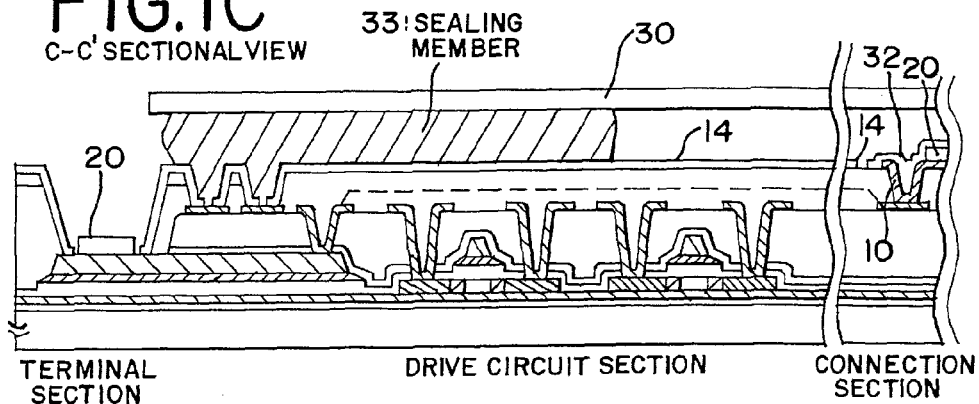


FIG. 2

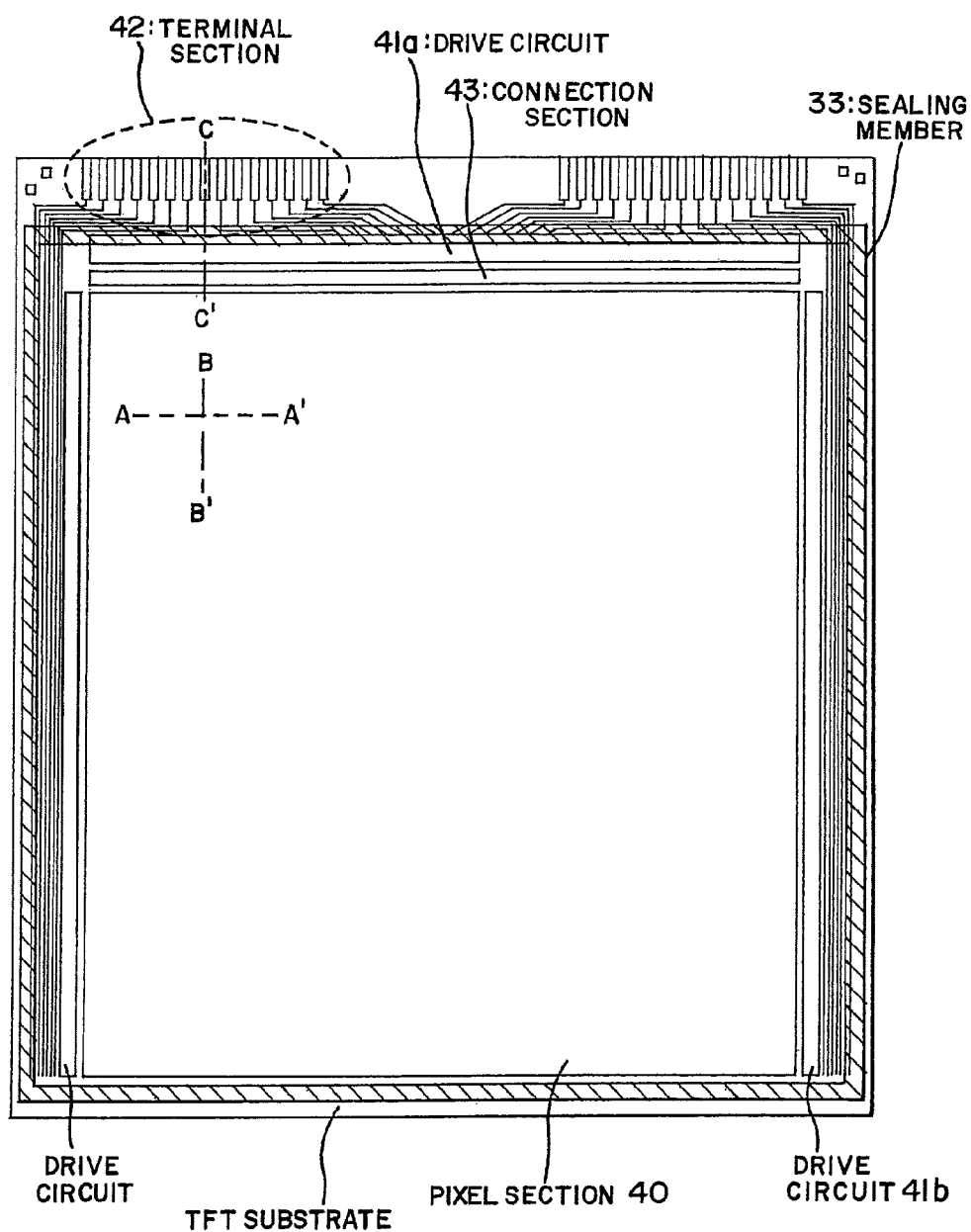


FIG. 3A

IDEAL MODEL DIAGRAM

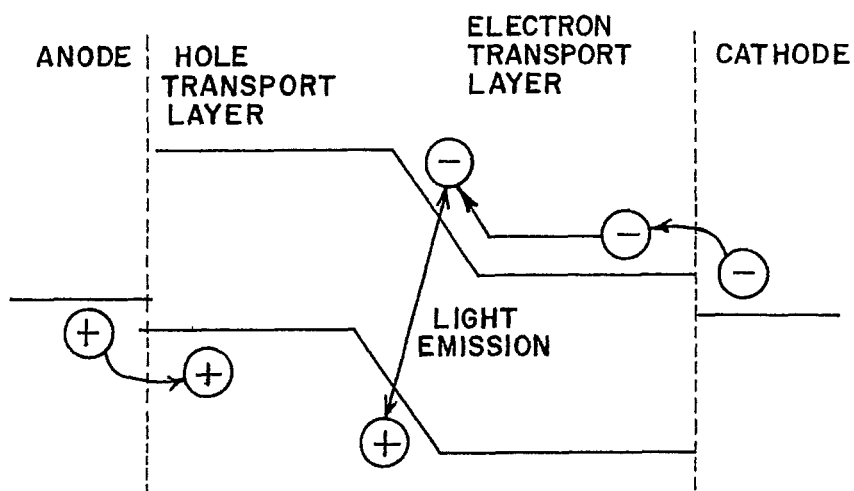


FIG. 3B

MODEL DIAGRAM

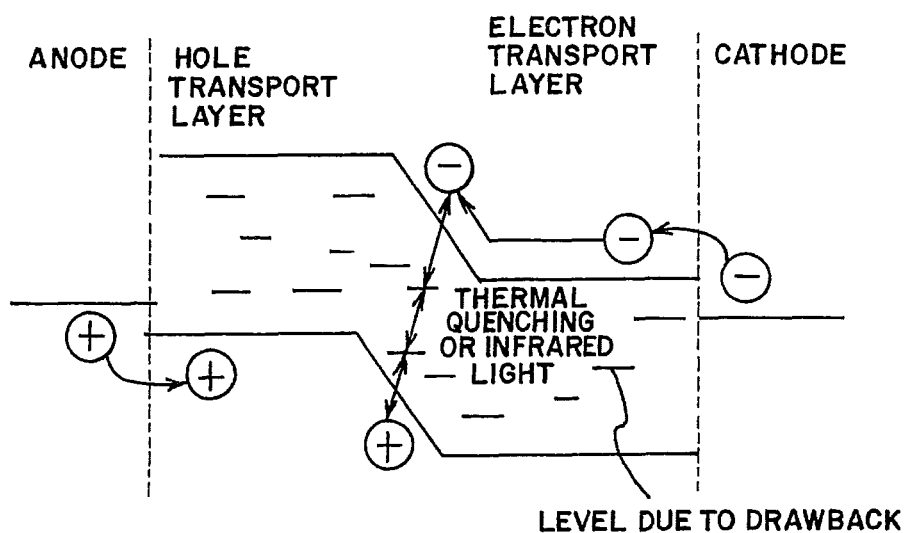


FIG. 4A

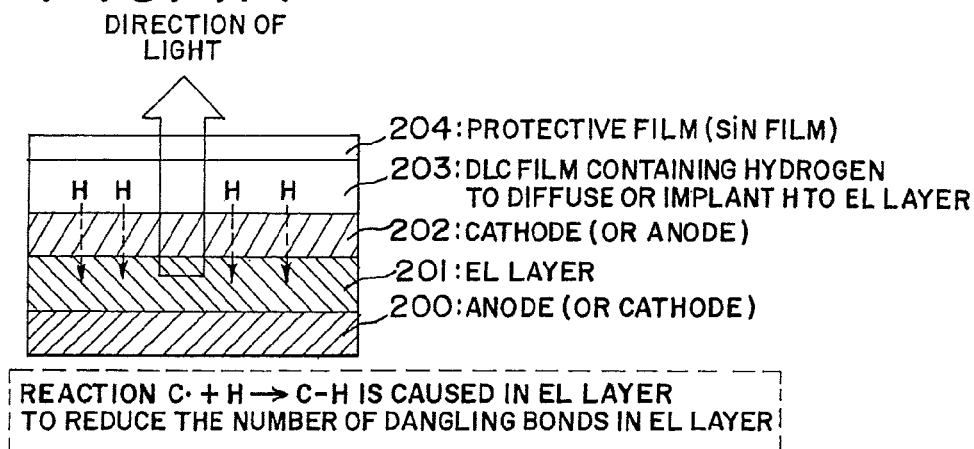


FIG. 4B

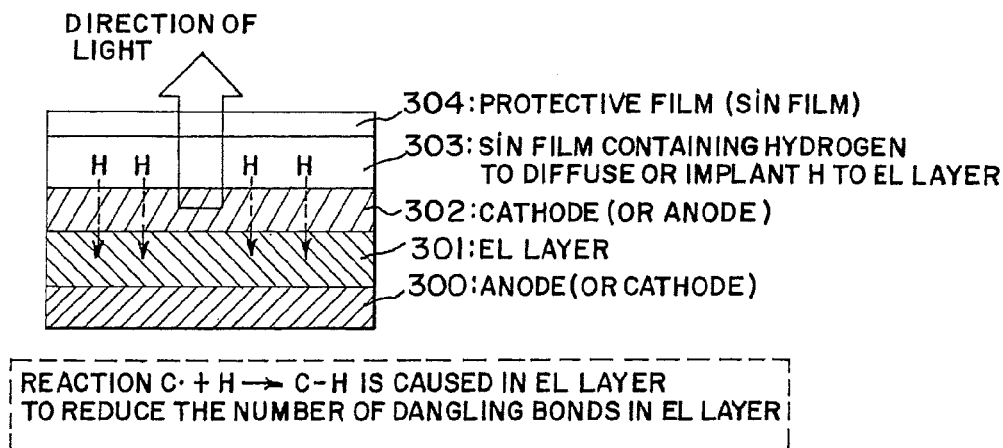


FIG. 4C

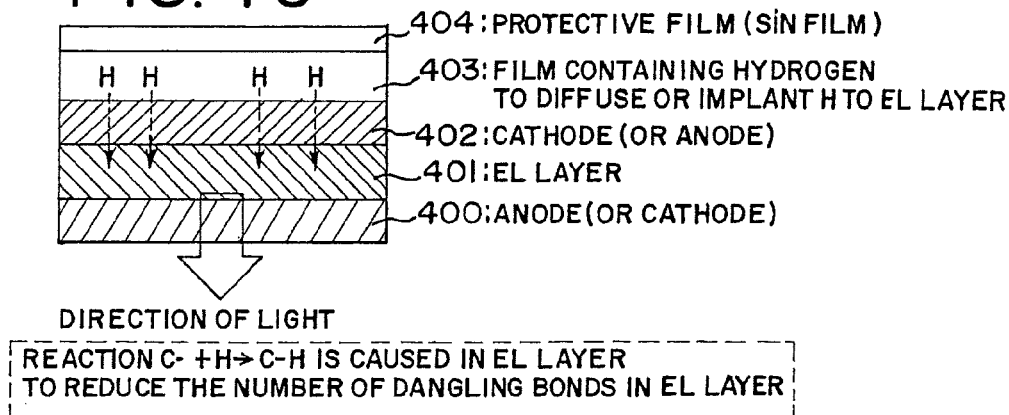


FIG. 5A

A-A' SECTIONAL VIEW

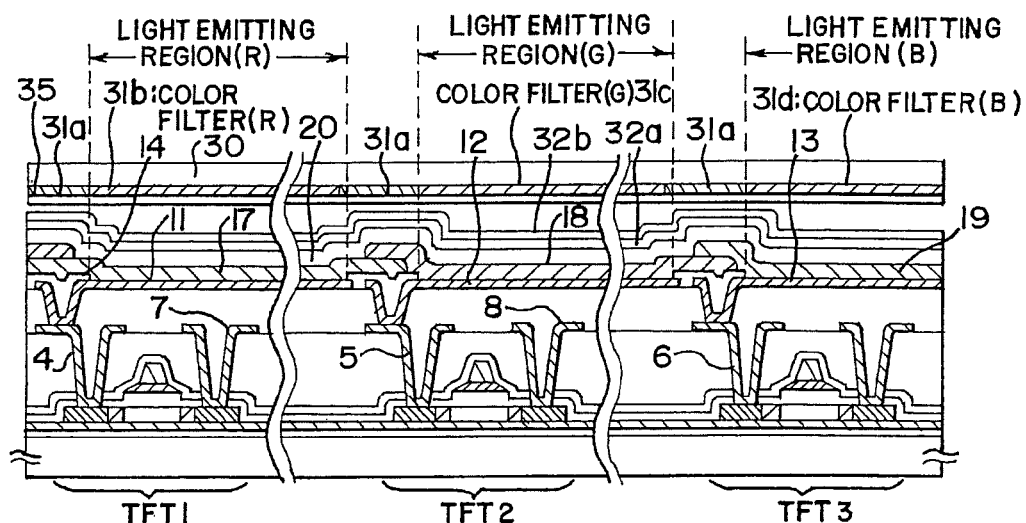


FIG. 5B

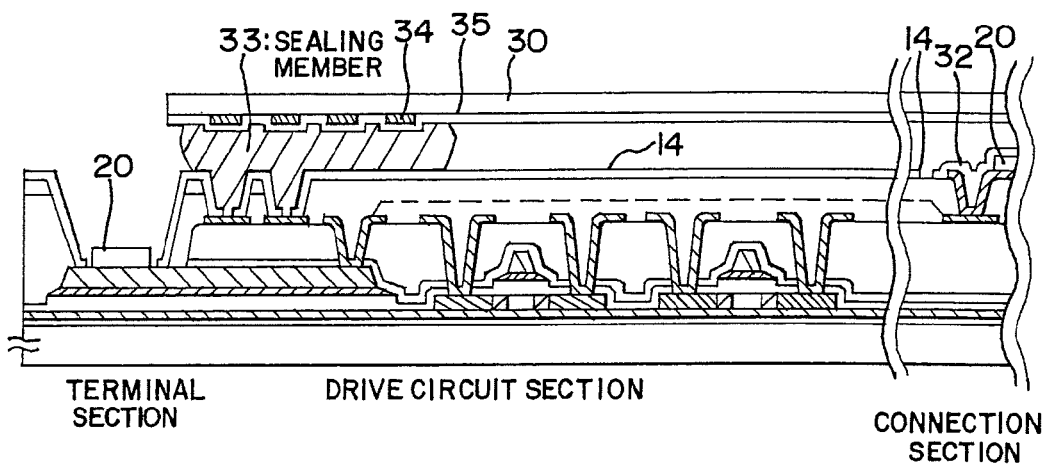




FIG. 6

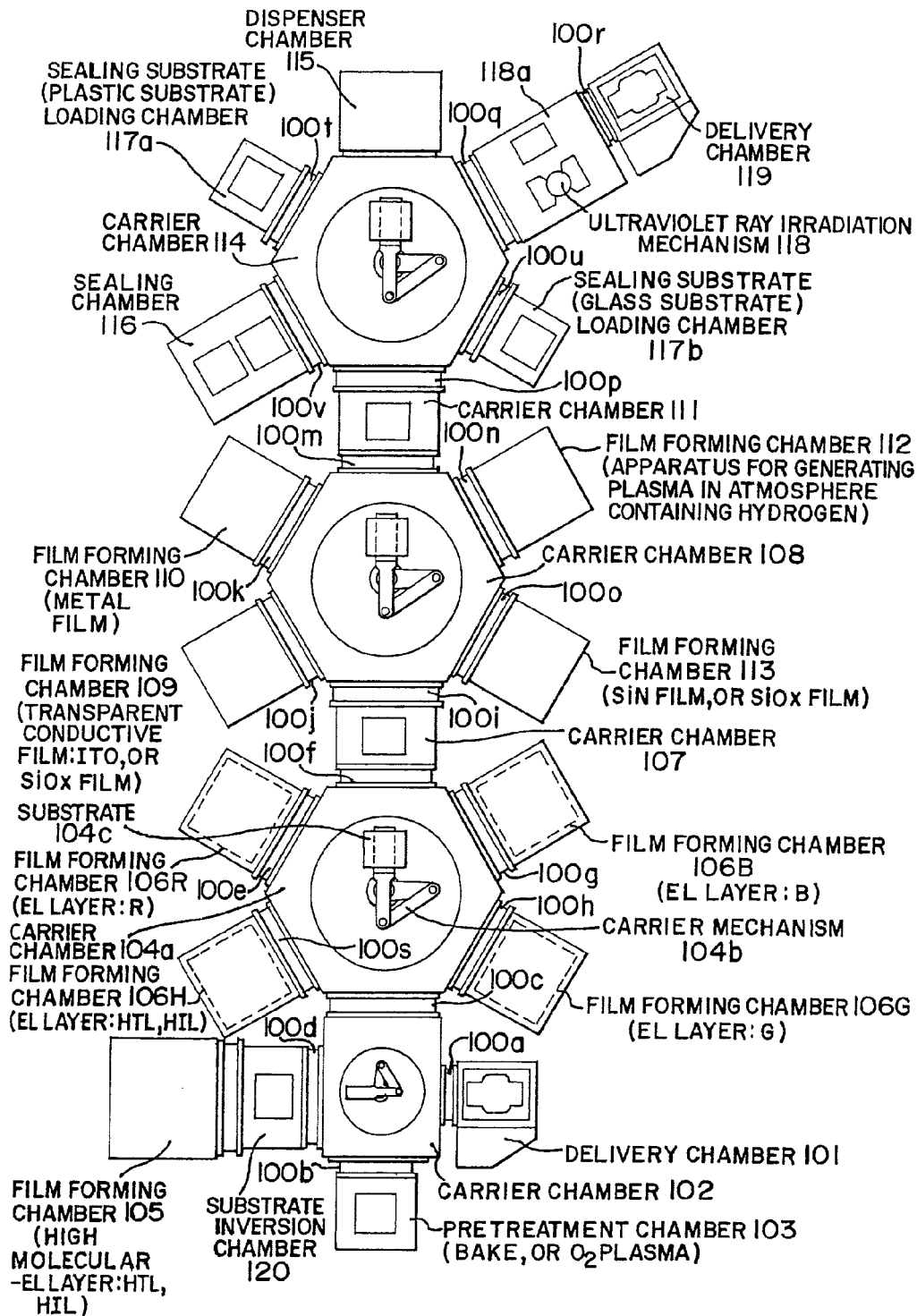


FIG. 7

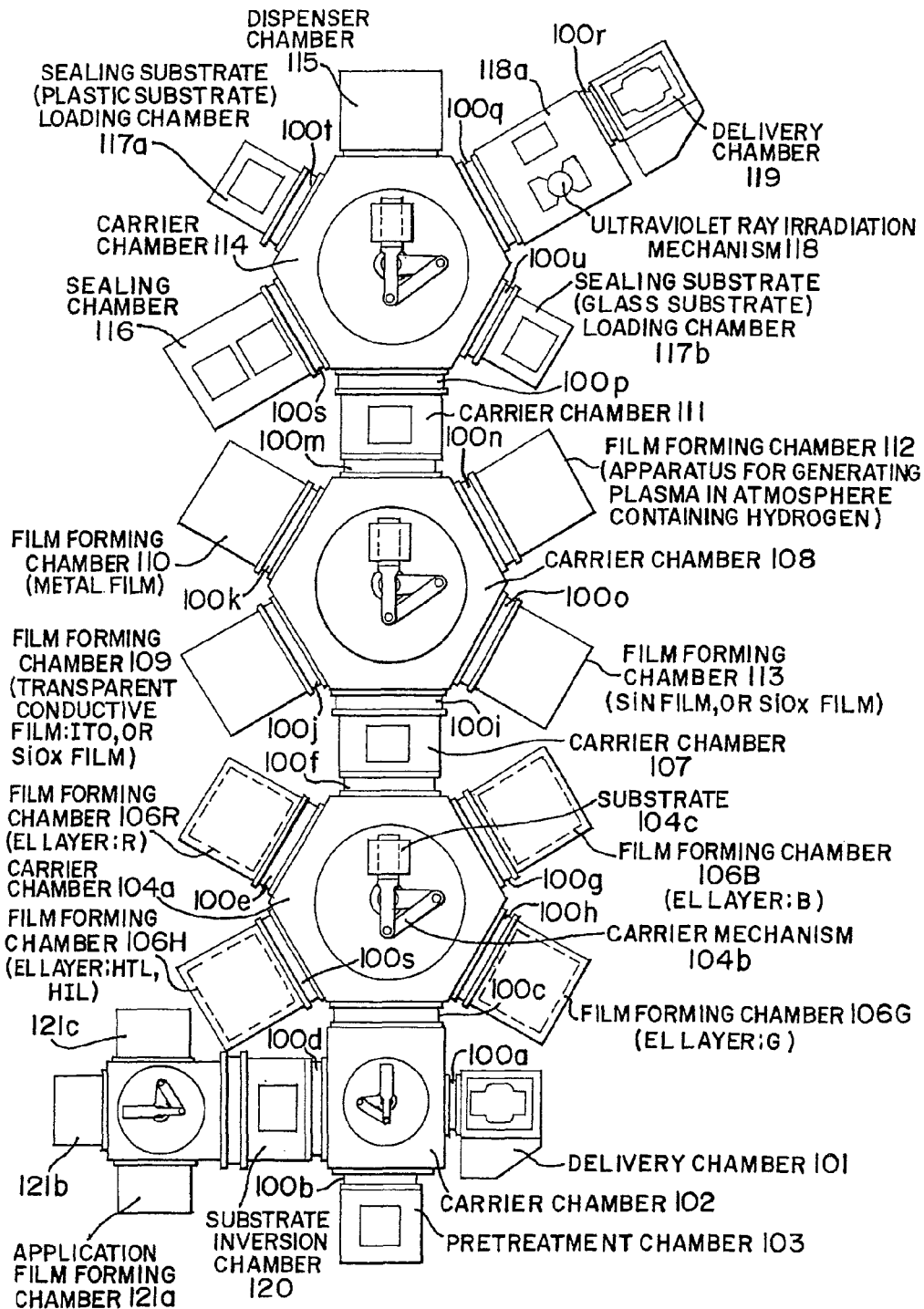




FIG.9A

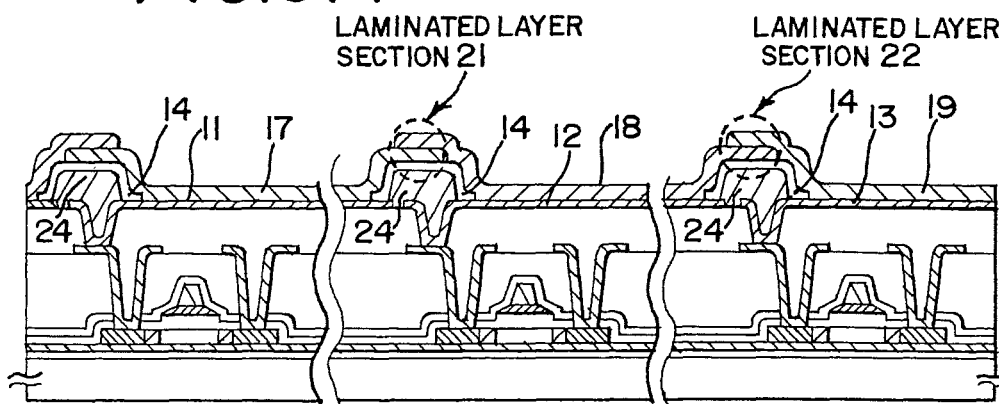
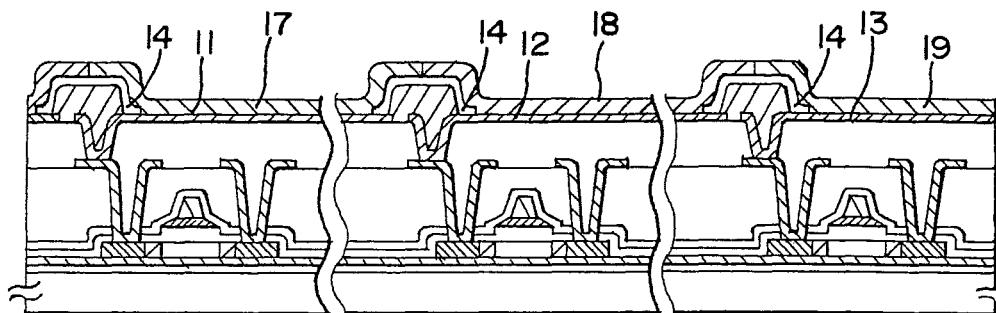


FIG.9B



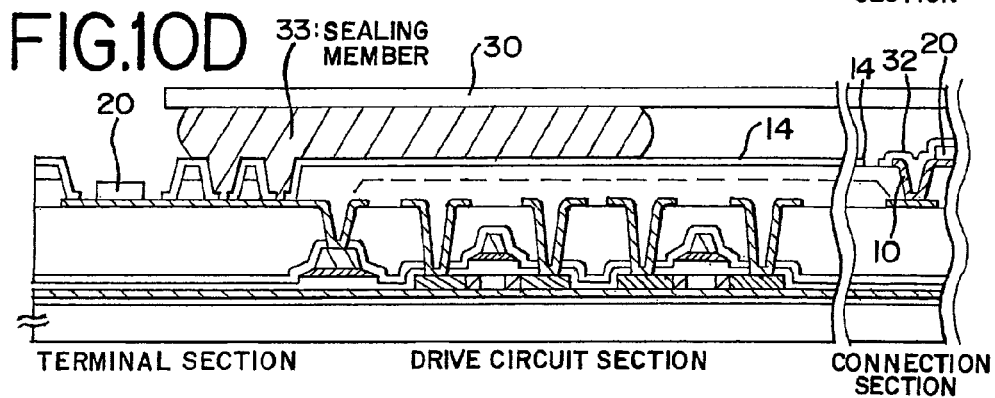
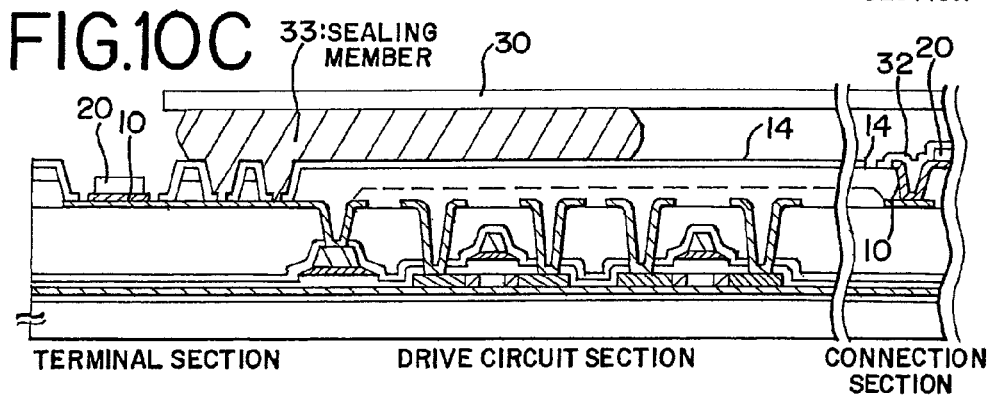
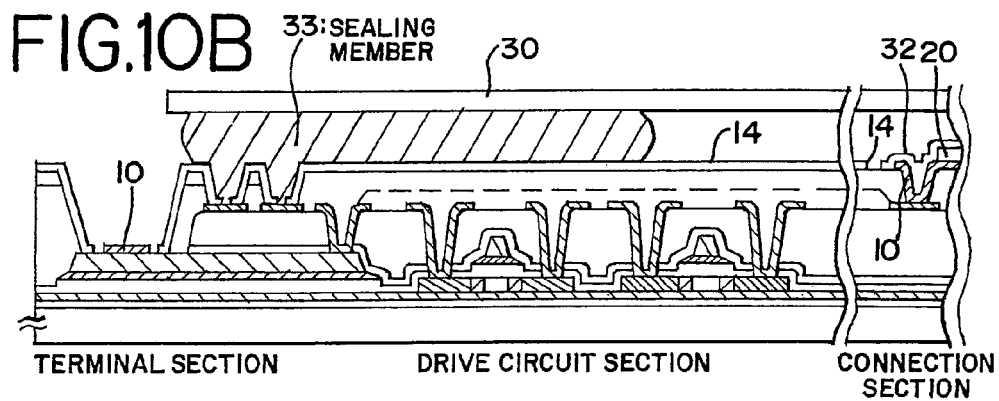
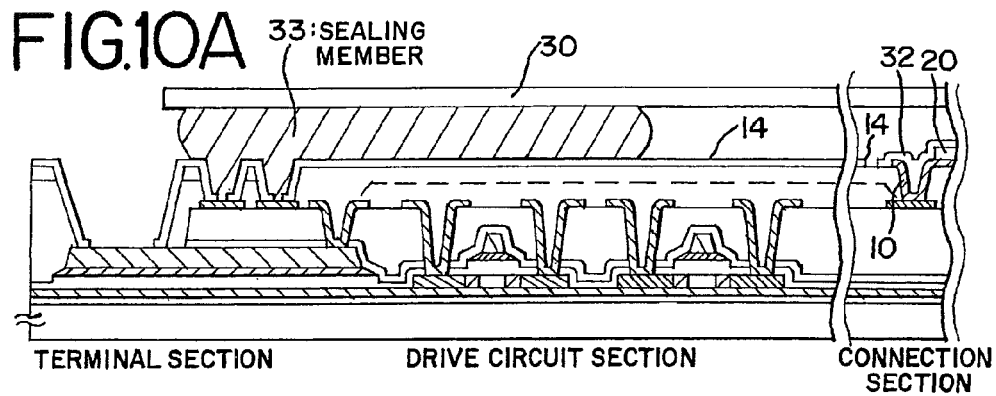


FIG.11A

A-A' CROSS-SECTIONAL VIEW

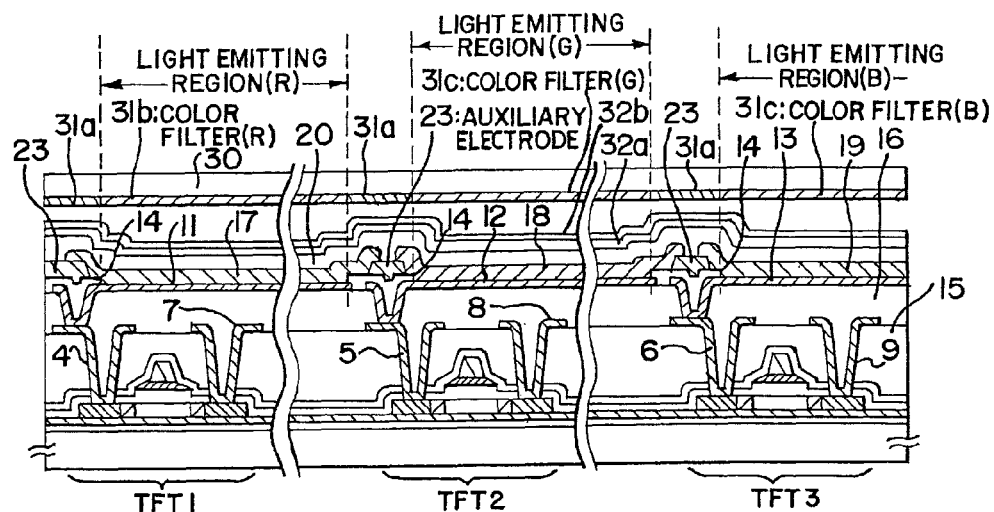


FIG.11B

B-B' CROSS-SECTIONAL VIEW

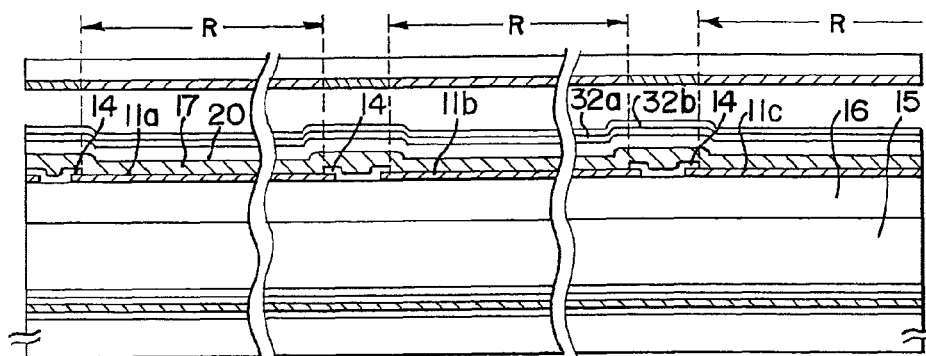


FIG.11C

C-C' CROSS-SECTIONAL VIEW

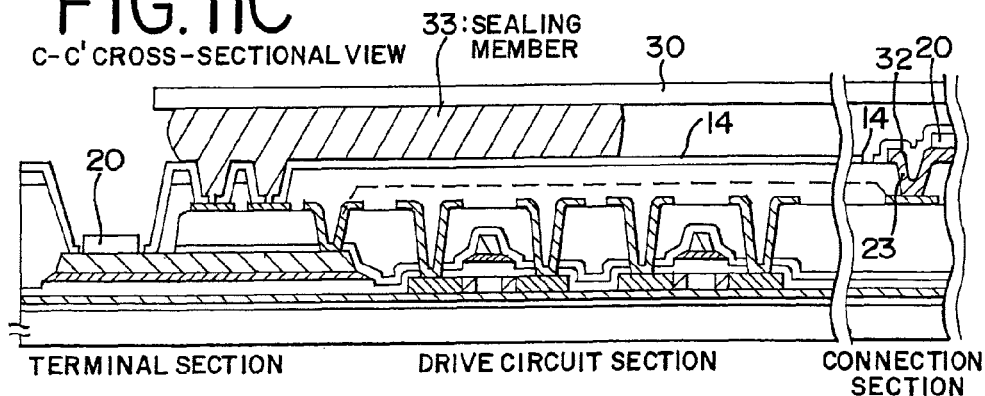


FIG. 12

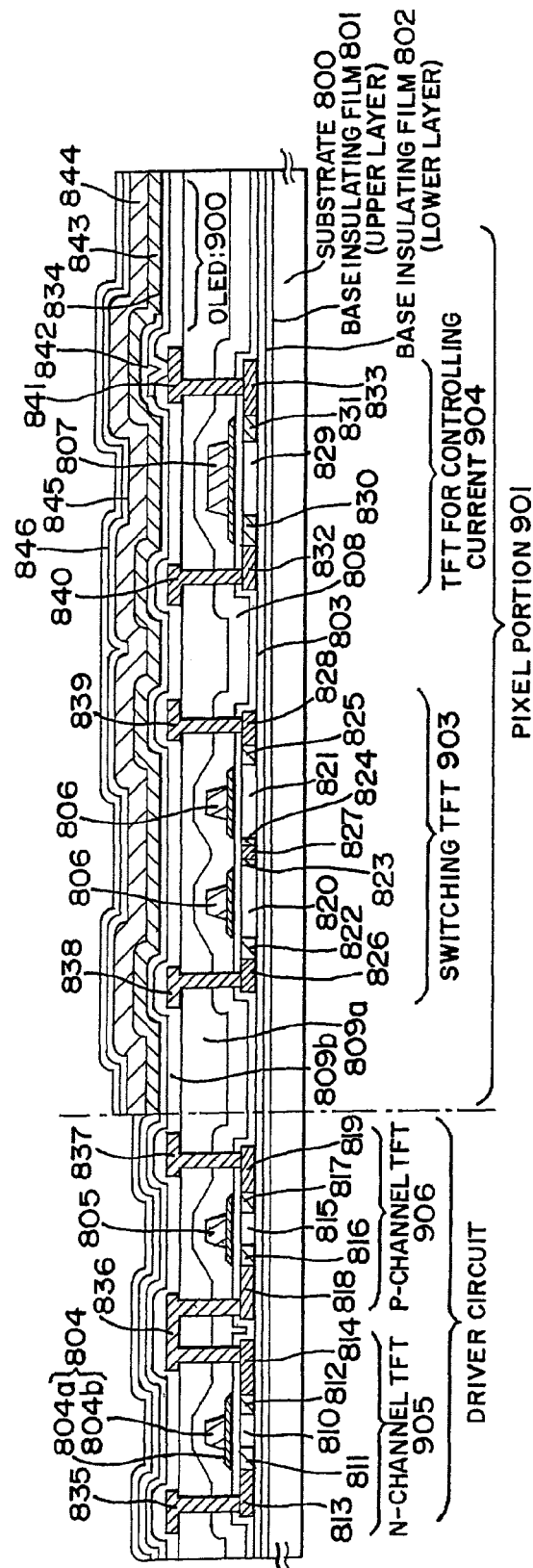


FIG.13A

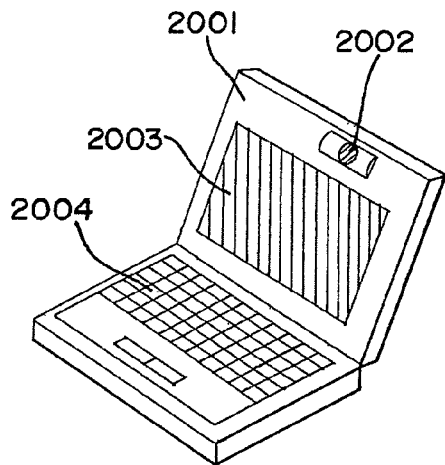


FIG.13B

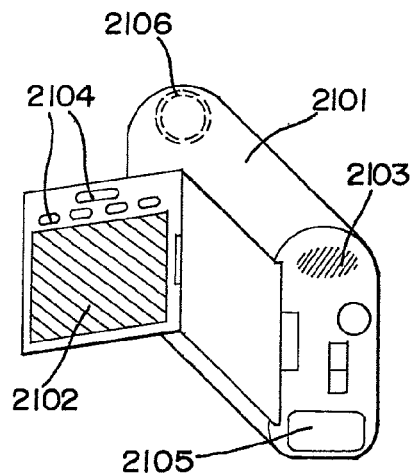


FIG.13C

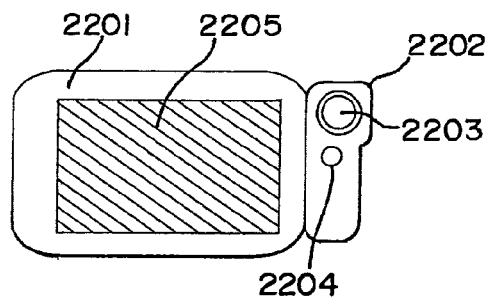


FIG.13D

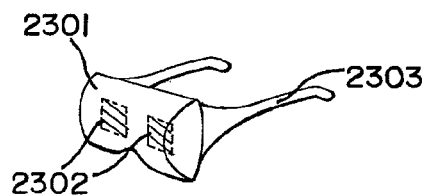


FIG.13E

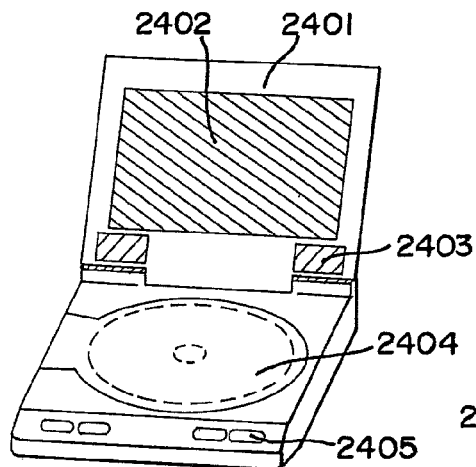
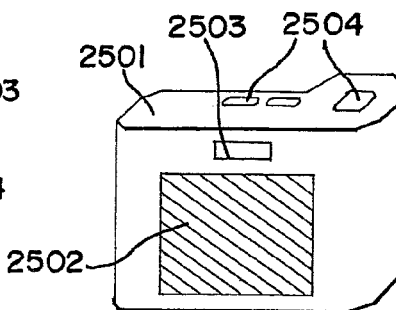
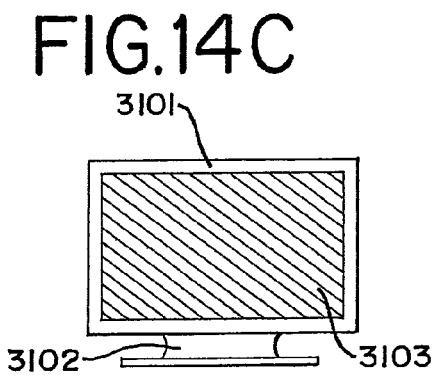
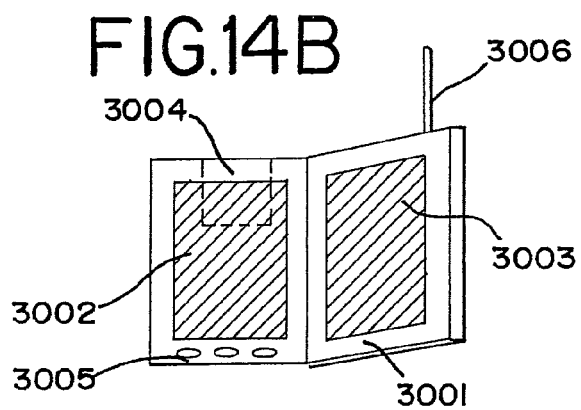
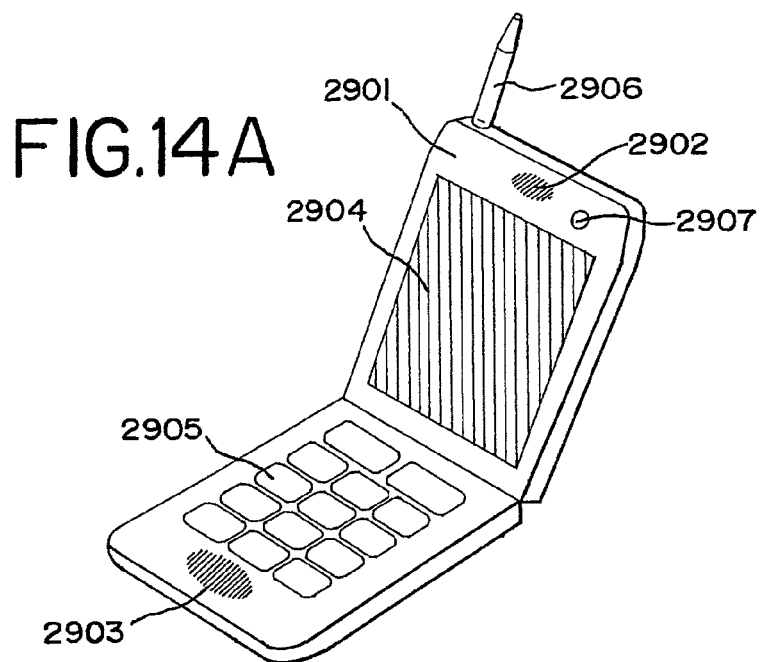


FIG.13F







## LIGHT EMITTING DEVICE

This application is a continuation of copending U.S. application Ser. No. 11/476,508, filed on Jun. 28, 2006 which is a divisional of U.S. application Ser. No. 10/349,750, filed on Jan. 22, 2003 (now U.S. Pat. No. 7,098,069 issued Aug. 29, 2006), which are all incorporated herein by reference.

### BACKGROUND OF THE INVENTION

#### 1. Field of the Invention

The present invention relates to a semiconductor device, in particular, the present invention relates to a light emitting device having a light emitting element formed on a substrate having an insulating surface and method of manufacturing thereof. Further, the present invention relates to an organic light emitting module on which ICs and the like, including a controller, are mounted to an organic light emitting panel. Note that the terms organic light emitting panel and organic light emitting module both generically refer to light emitting devices in this specification. The present invention additionally relates to an apparatus for manufacturing the light emitting device.

In this specification, semiconductor devices correspond to general devices functioning by use of semiconductor characteristics. Therefore, a light emitting device, an electro-optical device, a semiconductor circuit and an electronic device are all included in the category of the semiconductor device.

#### 2. Description of the Related Art

In recent years, techniques of forming TFTs (thin film transistors) on substrates have been progressing greatly, and developments in their application to active matrix type display devices is advancing. In particular, TFTs that use polysilicon films have a higher electric field effect mobility (also referred to as a mobility) than TFTs that use conventional amorphous silicon films, and therefore high speed operation is possible. Developments in performing control of pixels by forming driver circuits made from TFTs that use polysilicon films on a substrate on which the pixels are formed have therefore been flourishing. It has been expected that various advantages can be obtained by using active matrix type display devices, in which pixels and driver circuits are mounted on the same substrate, such as reductions in manufacturing cost, miniaturization of the display device, increases in yield, and reductions in throughput.

Furthermore, research on active matrix type light emitting devices using organic light emitting elements as self light emitting elements (hereinafter referred to simply as light emitting devices) has become more active.

Switching elements composed of TFTs (hereinafter referred to as switching elements) are formed for each pixel in active matrix type light emitting devices, and driver elements for performing electric current control by the switching TFTs (hereinafter referred to as electric current control TFTs) are operated, thus making EL layers (specifically, light emitting layers) emit light. For example, a light emitting device disclosed in Japan Patent Laid-Open No. 10-189252 A is known.

Organic light emitting elements are self light emitting, and therefore have high visibility. Backlights, necessary for liquid crystal display devices (LCDs), are not required for organic light emitting elements, which are optimal for making display devices thinner and have no limitations in viewing angle. Light emitting devices using the organic light emitting elements are consequently being focused upon as substitutes for CRTs and LCDs.

Note that EL elements have a layer containing an organic compound in which luminescence develops by the addition of

an electric field (electroluminescence) (hereinafter referred to as EL layer), an anode, and a cathode. There is light emission when returning to a base state from a singlet excitation state (fluorescence), and light emission when returning to a base state from a triplet excitation state (phosphorescence) in the organic compound layer, and it is possible to apply both types of light emission to light emitting devices manufactured by the manufacturing apparatus and film formation method of the present invention.

The EL elements have a structure in which an EL layer is sandwiched between a pair of electrodes, and the EL layer normally has a laminate structure.

A laminate structure of "a hole transporting layer/a light emitting layer/electron transporting layer" can be given as a typical example. This structure has extremely high light emitting efficiency, and at present almost all light emitting devices undergoing research and development employ this structure.

Further, a structure in which: a hole injecting layer, a hole transporting layer, a light emitting layer, and an electron transporting layer are laminated in order on an anode; or a hole injecting layer, a hole transporting layer, a light emitting layer, an electron transporting layer, and an electron injecting layer are laminated in order on an anode may also be used. Fluorescent pigments and the like may also be doped into the light emitting layers. Further, all of the layers may be formed by using low molecular weight materials, and all of the layers may be formed by using high molecular weight materials.

### SUMMARY OF THE INVENTION

Concerning an organic compound material constituting an EL layer (strictly speaking, that is, light emitting layer) which can be referred to as a center of an EL element, a short chain based organic compound material and a polymer molecule based (polymer based) organic compound material have been investigated, respectively.

As a method of forming these organic compound materials into a film, an ink jet method, a vapor deposition method, a spin coating method and the like are known.

However, in the case where a flat panel display of full colors using the emitting colors of red, green and blue is to be prepared, since the deposition precision is not so high, it is designed so that the interval between different pixels is widened, or an insulator which is called as a "bank" is provided between the pixels.

Moreover, as a flat panel display of full colors using red, green and blue, the requirements for a high definition, a high aperture efficiency and a high reliability has been heightened. Such requirements have been big problems in seeking for the high definition (increase of the number of pixels) of a light emitting device and miniaturization of the respective display pixel pitch accompanied with downsizing of the device. Moreover, at the same time, the requirements for the enhancement of the productivity and the lowering of the cost have been also heightened.

In addition, the present invention is also directed to enhance the reliability and brightness of a light emitting element. The present invention realizes the high definition and high aperture efficiency of a product for a flat panel display of full colors using luminescent colors of red, green and blue without being dependent upon a method of forming an organic compound layer and the deposition precision by intentionally overlapping one portion of different organic compound layers of the adjacent light emitting elements.

However, an inorganic insulating film is provided between the portion where one portion of different organic compound layers are overlapped and a pixel electrode, this inorganic

insulating film covers both ends of the respective pixel electrodes and intervals between them. It should be noted that even in the case where the other organic compound layer has superimposed onto the organic compound layer being in contact with the pixel electrode, since the emission brightness is lowered to about  $\frac{1}{1000}$  and the flowing current also becomes about  $\frac{1}{1000}$ , no problem occurs. In the configuration 1 of the present invention disclosed in the present specification, a light emitting device is characterized in that,

the foregoing light emitting device has a plurality of light emitting elements having a cathode, an organic compound layer being in contact with the relevant cathode and an anode being contact with the relevant organic compound layer, in which,  
 a first light emitting element having a first organic compound layer,  
 a second light emitting element having a second organic compound layer, and  
 a third light emitting element having a third organic compound layer have been arranged, and which,  
 has an insulator for covering the ends of the foregoing anode, and in which the foregoing first organic compound layer, the foregoing second organic compound layer or the foregoing third organic compound layer has been provided on the relevant insulator and the foregoing anode.

In the configuration 2 of the present invention disclosed in the present specification, a light emitting device is characterized in that,

the foregoing emitting device has a plurality of light emitting elements having a cathode, an organic compound layer being in contact with the relevant cathode and an anode being in contact with the relevant organic compound layer, in which,  
 a first light emitting element having a first organic compound layer,  
 a second light emitting element having a second organic compound layer, and  
 a third light emitting element having a third organic compound layer have been arranged, and which,  
 has an insulator for covering the ends of the foregoing cathode, and in which the foregoing first organic compound layer, the foregoing second organic compound layer or the foregoing third organic compound layer has been provided on the relevant insulator and the foregoing cathode.

Moreover, concerning an active matrix type light emitting device, two types of structures are contemplated from the viewpoint of radiation direction of the light. One is a structure in which the light emitted from an EL element transmits through the opposing substrate and irradiated to the observer's eyes. In this case, the observer can recognize an image from the opposing substrate side. The other is a structure in which the light emitted from an EL element transmits through the element substrate and irradiated to the observer's eyes. In this case, the observer can recognize an image from the element substrate side.

Moreover, in the above-described respective configurations, the foregoing insulator is characterized in that it is a barrier (also referred to as bank) composed of an organic resin covered by an inorganic insulating film or an inorganic insulating film. It should be noted that the foregoing inorganic insulating film is characterized in that it is an insulating film whose film thickness is in the range from 10 to 100 nm and whose major component is silicon nitride. Moreover, as an insulator for covering ends of a cathode or an anode, a film containing hydrogen, representatively, a thin film whose major component is carbon or a silicon nitride film may be used.

In addition, it is extremely useful that as an anode, a transparent conductive film (representatively, ITO, ZnO) is used, and further, on which, a protective film composed of an inorganic insulating film is formed.

Furthermore, it is preferable that prior to the formation of the protective film composed of an inorganic insulating film, a film containing hydrogen (representatively, thin film (DLC film) whose major component is carbon, silicon nitride film, silicon oxynitride film, silicon oxide film or laminated film thereof) is formed by a plasma CVD method or a sputtering method. Moreover, it is preferable that a silicon nitride film as a protective film is formed by covering the foregoing film containing hydrogen. Moreover, in the above-described respective configurations, the foregoing first light emitting element is characterized in that it emits any one of color out of red color, green color or blue color. Moreover, the foregoing first light emitting element, the foregoing second light emitting element and the foregoing third light emitting element are characterized in that these emit colors different from each other.

Moreover, in the above-described respective configurations, it is preferable that in a sealing, the whole of a light emitting element is sealed using a sealing substrate, for example, a glass substrate or a plastic substrate.

Moreover, in a light emitting device, there has been a problem such that an incident light from the exterior (light from the exterior of the light emitting device) is reflected by the backside of a cathode (surface of the side being in contact with the light emitting layer) in a pixel not emitting the light, the backside of the cathode acts as a mirror, and the exterior landscape is projected on the observation surface (surface facing to the observer side). Moreover, in order to avoid this problem, it has been devised such that a circularly polarized light film was pasted on the observation surface of the light emitting device, but there has been a problem that since the cost of the circularly polarized light film is very high, it causes the increase of the manufacturing cost.

An object of the present invention is to prevent a light emitting device from being mirror plate without using a circularly polarized film, by means of this, the present invention is directed to reduce the manufacturing cost of a light emitting device, and also to provide a cheap light emitting device. Hence, in the present invention, it is characterized in that instead of a circularly polarized film, a cheap color filter is used. In the above-described configuration, in order to enhance the color purity, it is preferable that the foregoing light emitting device is equipped with a color filter corresponding to the respective pixel. Moreover, it may be made so that the portion of the black color of the color filter (black color organic resin) is overlapped with the interval between the respective light emitting regions. Furthermore, it may be also configured so that the portion of the black color of the color filter is partially overlapped with the different organic compound layer.

However, in the outgoing direction of emission, specifically, between the foregoing light emitting element and the observer, a color filter is provided. For example, in the case where it is not transmitted through the substrate on which the light emitting element is provided, a color filter may be pasted on the sealing substrate. Or, in the case where it is transmitted through the substrate on which the light emitting element is provided, the color filter may be pasted on the substrate on which the light emitting element is provided. By thus doing it, the circularly polarized film becomes unnecessary.

Moreover, the biggest problem among the practical applications of an EL element is the fact that the lifespan of an element is insufficient. Moreover, the deterioration of an ele-

5

ment appears in a form where non-light emitting region (dark spot) is widened accompanying with emitting the light for long time, and the deterioration of an EL layer becomes a big problem as a causing factor of it.

In order to solve the problem, the present invention is characterized in that plasma is generated under the atmosphere containing hydrogen and the drawbacks in the organic compound layer are terminated with hydrogen. The other configuration 3 of the present invention is characterized in that it has,

a light emitting element on the substrate having an insulation surface, the relevant light emitting element has an anode, a cathode and an organic compound layer sandwiched between the foregoing anode and the foregoing cathode, and

the foregoing light emitting element is covered with a film containing hydrogen.

The drawback in an organic compound layer can be terminated with hydrogen by diffusing hydrogen from the above-described film containing hydrogen by means of performing the heating treatment in a temperature range where the organic compound layer is durable or by means of utilizing the heat generation generated at the time when the light emitting element emits the light. Once the drawback in the organic compound layer, representatively, a dangling bond is terminated with hydrogen, the reliability for a light emitting device is enhanced. Moreover, when the above-described film containing hydrogen is formed in a film, the drawback in the organic compound layer may be terminated with hydrogen by diffusing or implanting hydrogen which has been made plas-  
matic. By thus performing, unstable bonds existed in the organic compound layer or generated by any of the causing factors (heat generation generated at the time when it emits, irradiation of light, change of temperatures, and the like) can be reduced. Therefore, the enhancement of the reliability and brightness as a light emitting element can be realized. Moreover, the protective layer for covering and forming the film containing hydrogen blocks hydrogen diffusing to the protective layer side and efficiently diffusing hydrogen into an organic compound layer and plays a role for terminating the drawback in the organic compound layer with hydrogen. Moreover, in order to make hydrogen transmit through a cathode or an anode formed on the organic compound layer and diffuse hydrogen, it is preferable that the thickness of the cathode or anode is made thinner. However, the cathode or anode formed on the organic compound layer is protected not to damage the organic compound layer at the time when the film containing hydrogen is formed. Moreover, the above-described film containing hydrogen can be functioned as a protective film of a light emitting element. Furthermore, the above-described film containing hydrogen can be functioned as a buffer layer, in the case where a silicon nitride film is formed in a state where it is in contact with a film composed of a transparent conductive film by a sputtering method, it is feared that impurities (In, Sn, Zn and the like) contained in the transparent conductive film is contaminated into the silicon nitride film. However, the impurities contamination into the silicon nitride film can be prevented by forming the above-described film containing hydrogen which is to be a buffer layer between two films. The contamination of the impurities (In, Sn and the like) from the transparent conductive film is prevented and an excellent protective film without any impurities can be formed.

Moreover, a preparation method for realizing the above-described configurations is also one of the present invention, the constitution relating to the preparation method of the present invention is,

6

a method of preparing a light emitting device characterized in that a TFT is formed on an insulation surface, a cathode electrically connected to the foregoing TFT is formed, an organic compound layer is formed on the foregoing cathode, after an anode has been formed on the foregoing organic compound layer, and a film containing hydrogen is formed on the foregoing anode. Moreover, the other constitution relating to a preparation method of the present invention is,

a method of preparing a light emitting device characterized in that a TFT is formed on an insulation surface, an anode electrically connected to the foregoing TFT is formed, an organic compound layer is formed on the foregoing anode, and after a cathode has been formed on the foregoing organic compound layer, a film containing hydrogen is formed on the foregoing cathode.

Moreover, in the above-described respective constitutions relating to a preparation method of the present invention, the foregoing film containing hydrogen is characterized in that it is formed in the temperature range where the foregoing organic compound layer is durable, for example, in the range from room temperature to 100° C. or less by a plasma CVD method or a sputtering method, and the foregoing film containing hydrogen is characterized in that it is a thin film whose major component is carbon or it is a silicon nitride film.

Moreover, in the above-described respective constitutions relating to a preparation method of the present invention, a step of forming the foregoing organic compound layer is characterized in that it is carried out by a vapor deposition method, a coating method, an ion plating method or an ink jet method.

Moreover, in the above-described constitutions relating to a preparation method of the present invention, the present invention is characterized in that a protective film composed of an inorganic insulating film is formed on the foregoing film containing hydrogen.

Moreover, in the above-described constitutions relating to a preparation method of the present invention, the present invention is characterized in that at the time when the foregoing film containing hydrogen is formed, the drawback in the foregoing organic compound layer is terminated with hydrogen.

Moreover, in order to prevent the deterioration by moisture or oxygen, at the time when a light emitting element is sealed with a sealing can or a sealing substrate, hydrogen gas may be filled in the space to be sealed or hydrogen and inert gas (rare gas or nitrogen) may be filled.

Moreover, it has been made that in the above-described preparation method at the time when the film is formed, the drawbacks in the foregoing organic compound layer are terminated with hydrogen, but it is not particularly limited to that. Even if the film is not formed, only hydrogen plasma treatment may be performed. The other constitution relating to a preparation method of the present invention is characterized in that it comprises,

in a method of preparing a light emitting device having a plurality of light emitting elements having an anode, an organic compound layer which is in contact with the relevant anode and superimposed on the anode, a cathode which is in contact with the organic compound layer and superimposed on the organic compound layer, a first step of forming an organic compound layer on the anode,

a second step of performing the treatment for terminating the drawback with hydrogen in the foregoing organic compound layer by generating a plasma under the atmo-

sphere containing hydrogen after the formation of the foregoing organic compound layer, and  
a third step of forming a cathode on the foregoing organic compound layer.

Moreover, hydrogen plasma treatment may be performed immediately after the organic compound layer has been formed, other constitution relating to a preparation method of the present invention is characterized in that it comprises,

in a method of preparing a light emitting device having a plurality of light emitting elements having an anode, an organic compound layer which is in contact with the relevant anode and superimposed on the anode, a cathode which is in contact with the organic compound layer and superimposed on the organic compound layer,

a first step of forming an organic compound on the anode, a second step of forming a cathode on the foregoing organic compound layer, and

a third step of performing the treatment for terminating the drawbacks in the foregoing organic compound layer with hydrogen by generating a plasma under the atmosphere containing hydrogen after the formation of the foregoing cathode.

Moreover, other constitution relating to a preparation method of the present invention is characterized in that it comprises,

in a method of preparing a light emitting device having a plurality of light emitting elements having a cathode, an organic compound layer which is in contact with the relevant cathode and superimposed on the cathode, an anode which is in contact with the relevant organic compound layer and superimposed on the organic compound layer,

a first step of forming an organic compound layer on the cathode,

a second step of forming an anode on the foregoing organic compound layer, and

a third step of performing the treatment for terminating the drawbacks in the foregoing organic compound layer with hydrogen by generating a plasma under the atmosphere containing hydrogen after the formation of the foregoing anode.

Moreover, hydrogen plasma treatment may be performed immediately after the organic compound layer has been formed, other constitution relating to a preparation method of the present invention is characterized in that it comprises,

in a method of preparing a light emitting device having a plurality of light emitting elements having a cathode, an organic compound layer which is in contact with the relevant cathode and superimposed on the cathode, an anode which is in contact with the relevant organic compound layer and superimposed on the organic compound layer,

a first step of forming an organic compound on the cathode,

a second step of performing the treatment for terminating the drawbacks in the foregoing organic compound layer with hydrogen by generating a plasma under the atmosphere containing hydrogen after the formation of the foregoing organic compound layer, and

a third step of forming an anode on the foregoing organic compound layer.

It should be noted that in the present specification, all of the layers provided between a cathode and an anode is generally referred to as an EL layer. Therefore, the above-described hole injection layer, hole transport layer, light emitting layer, electron transport layer and electron injection layer are all contained in the EL layer.

In the present invention, a thin film whose major component described above is carbon is characterized in that it is a DLC (Diamond Like Carbon) film of 3-50 nm in the film thickness. The DLC film has a  $SP^3$  bonding as a carbon-carbon bonding in a short range order, but in macro range order, it has an amorphous structure. The composition of the DLC film is composed of 70-95 atom % of carbon and 5-30 atom % of hydrogen, is very hard and excellent in insulation. The DLC film thus formed is characterized in that gas transmittance such as water vapor, oxygen and the like is low. Moreover, it is known that it has a hardness of 15-25 GPa by the measurement of micro-hardness meter.

The DLC film can be formed by plasma CVD method (representatively, RF plasma CVD method, microwave CVD method, electron cyclotron resonance (ECR) CVD method and the like), a sputtering method and the like. The DLC film can be formed with excellent adhesion by any film formation method. The DLC film is formed by setting a cathode on the substrate. Or, a film being dense and hard can be formed by applying a negative bias and by utilizing an ion bombardment to some extent.

As for a reactant gas used for forming a film, hydrogen gas and hydrocarbon based gas (for example,  $CH_4$ ,  $C_2H_2$ ,  $C_6H_6$  and the like) are used, ionized by glow discharge, an ion is accelerated and bombarded against the cathode which has been negatively self-biased, thereby forming a film. By thus performing, a DLC film being dense and smooth can be obtained.

Moreover, this DLC film is characterized in that it is an insulation film transparent or semi-transparent with respect to the visible light.

Moreover, in the present specification, "being transparent with respect to the visible light" means that the transmittance of the visible light is in the range from 80 to 100%, and "being semi-transparent with respect to the visible light" means that the transmittance of the visible light is in the range from 50 to 80%.

Moreover, the present invention provides a fabrication unit capable of fabricating a light emitting device having a high reliability.

Other constitution of the present invention is a constitution relating to a fabrication unit, characterized in that the fabrication unit comprises,

loading chamber, a first carrier chamber connected to the relevant chamber and the foregoing treatment chamber connected to the relevant first carrier chamber,

a second carrier chamber connected to the foregoing first carrier chamber, and a film forming chamber of a plurality of organic compound layers connected to the relevant second carrier chamber,

a third carrier chamber connected to the foregoing second carrier chamber, and a film forming chamber of a metal layer, a film forming chamber of a transparent conductive film connected to the relevant third carrier chamber, a treatment chamber equipped with means for generating a plasma under the atmosphere containing hydrogen, and a film forming chamber of a protective film, and

a fourth carrier chamber connected to the foregoing third carrier chamber, and a dispenser chamber, a sealing substrate loading chamber, and a sealing chamber connected to the relevant fourth carrier chamber.

The constitution relating to the above-described fabrication unit is characterized in that the foregoing pretreatment chamber has vacuum exhaust means, heating means, and plasma generation means. Moreover, in the above-described fabrication unit, the fabrication unit is characterized in that a device for forming an organic compound layer composed of a

polymer molecular material is connected to the foregoing first carrier chamber, and the device for forming an organic compound layer composed of the foregoing polymer molecular material is a device in which the film formation is performed by a spin coat method, a spray method, an ion plating method, or an ink jet method.

Moreover, in the constitution relating to the above-described device, a treatment chamber equipped with means for generating a plasma under the atmosphere containing hydrogen is characterized in that it is a film formation unit of a silicon nitride film or a film whose major component is carbon.

Moreover, in the constitution relating to the above-described fabrication unit, a film forming chamber of a plurality of organic compound layers connected to the foregoing second carrier chamber is characterized in that it has a vapor deposition source. Using a fabrication unit indicating the above-described constitution, a light emitting device in which an EL element is covered with a film containing hydrogen and a protective film can be prepared with good throughput.

#### BRIEF DESCRIPTION OF THE DRAWINGS

FIGS. 1A to 1C are diagrams showing sectional views (Embodiment 1);

FIG. 2 is a diagram showing the top view (Embodiment 1);

FIGS. 3A and 3B are diagrams showing a model diagram (Embodiment 2);

FIGS. 4A to 4C are diagrams showing a laminated structure of the present invention (Embodiment 2);

FIGS. 5A and 5B are diagrams showing sectional view (Embodiment 3);

FIG. 6 is a diagram showing one example of a fabrication unit (Embodiment 4);

FIG. 7 is a diagram showing one example of a fabrication unit (Embodiment 4);

FIGS. 8A to 8C are diagrams showing sectional views (Embodiment 1);

FIGS. 9A and 9B are diagrams showing sectional views (Embodiment 1);

FIGS. 10A to 10D are diagrams showing sectional views (Embodiment 1);

FIGS. 11A to 11C are diagrams showing sectional views (Embodiment 5);

FIG. 12 is a diagram showing a sectional view of an active matrix substrate (Example 1);

FIGS. 13A to 13F are diagrams showing examples of electronic devices; and

FIGS. 14A to 14C are diagrams showing examples of electronic devices.

#### DESCRIPTION OF THE PREFERRED EMBODIMENTS

Hereinafter, embodiment of the present invention will be described.

##### Embodiment 1

FIG. 2 is a top view of an EL module. On a substrate (referred to as TFT substrate) on which many TFTs are provided, a pixel section 40 where the display is performed, drive circuits 41a, 41b for driving the respective pixels of the pixel section, a connection section 43 connecting an electrode provided on the EL layer and the drawing wiring, and a terminal section 42 for pasting FPC for connecting with the exterior circuit are provided. Moreover, the EL element is sealed with

a substrate for sealing the EL element and a sealing member 33. Moreover, FIG. 1A is a sectional view taken on chain line A-A' of FIG. 2.

The pixels are disposed in order in the direction of the chain line A-A', now, an example in which R, G and B in turn are disposed in the X direction is exemplified. In the present invention, as shown in FIG. 1A, a laminated layer section 21 in which an EL layer 17 for emitting red color and an EL layer 18 for emitting green color are partially overlapped with each other is formed. Moreover, a laminated section 22, in which the EL layer 18 for emitting green color and the EL layer 19 for emitting blue color are partially overlapped with each other, is formed.

In this way, since the present invention makes the configuration in which the EL layer may be partially overlapped, a high definition and high aperture efficiency can be realized as a flat panel display of full colors using emitting colors of red, green and blue without depending upon a method of forming an organic compound layer (ink jet method, vapor deposition method, spin coating method and the like) and the deposition precision.

Moreover, in FIG. 1A, the light emitting region (R) indicates a light emitting region of red, the light emitting region (G) indicates a light emitting region of green, the light emitting region B indicates a light emitting region of blue, and a light emitting display device which has been fully colored is realized by these light emitting regions of three colors.

Moreover, in FIG. 1A, a TFT 1 is an element for controlling the current flowing in the EL layer 17 which emits red color, the reference numerals 4, 7 denote a source electrode or a drain electrode. Moreover, a TFT 2 is an element for controlling the current flowing in the EL layer 18 which emits green color, the reference numerals 5, 8 denote a source electrode or a drain electrode. A TFT 3 is an element for controlling the current flowing in the EL layer which emits blue color, the reference numerals 6, 9 denote a source electrode or a drain electrode. The reference numerals 15, 16 denote interlayer insulation films composed of an organic insulating material or an inorganic insulating film material.

Moreover, the reference numerals 11-13 denote an anode (or a cathode) of an organic light emitting element, the reference numeral 20 denotes a cathode (or anode) of an organic light emitting element. Here, for the cathode 20, it is made an electrode composed of a laminated layer film of a metal layer whose film thickness is 10 nm or less (representatively, alloy such as MgAg, MgIn, AlLi and the like) and a transparent conductive film (ITO (indium tin oxide alloy), indium oxide-zinc oxide alloy ( $\text{In}_2\text{O}_3\text{—ZnO}$ ), zinc oxide (ZnO) and the like), and the lights from the respective light emitting elements are transmitted through it. It should be noted that although a thin metal layer functions as a cathode of a light emitting element, in the present specification, a laminated layer film of a thin metal layer and a transparent conductive film is referred to as a cathode.

Moreover, both ends of the reference numerals 11-13 and the portion between them are covered with an inorganic insulator 14. Moreover, an organic compound layer is formed even on one portion on the inorganic insulator 14. The film thickness of the inorganic insulator 14 is 1  $\mu\text{m}$  or less, the film formed on the inorganic insulator 14 can be thinned as well as the coverage of the film formed on the inorganic insulator 14 can be made better. It should be noted that FIG. 1C is a sectional view taken on the chain line C-C' shown in FIG. 2. Moreover, In FIG. 1C, it is shown that the electrodes indicated with dotted line are electrically connected to each other. Moreover, in the terminal section, the electrode of terminal is formed with the same material with that of the cathode 20.

## 11

Moreover, a sealing substrate **30** is pasted with a sealing member **33** so as to maintain the interval of about 10  $\mu\text{m}$ , and all of the light emitting element is sealed. It should be noted that the sealing member **33** is preferably framed narrowly so that it overlaps one portion of a drive circuit. It is preferable that immediately before the sealing substrate **30** is pasted with the sealing member **33**, the degassing is carried out by performing the annealing in vacuum. Moreover, it is preferable that at the time when the sealing substrate **30** is pasted, it is performed under the atmosphere containing hydrogen and an inert gas (rare gas or nitrogen), hydrogen is made contained in the space sealed with the protective film **32**, the sealing member **33** and the sealing substrate **30**. The drawback in the organic compound layer can be terminated with hydrogen by utilizing the heat generation generated at the time when the light emitting element emits the light and by diffusing hydrogen from the space containing the above-described hydrogen. Terminating the drawback in the organic compound layer with hydrogen, the reliability for a light emitting device is enhanced. Furthermore, in order to enhance the color purity, the color filters corresponding to the respective pixels are provided in the sealing substrate **30**. Out of the color filters, the red colored layer **31b** is provided opposing to the red color light emitting region (R), the green colored layer **31c** is provided opposing to the green color light emitting region (G) and the blue colored layer **31d** is provided opposing to the blue color light emitting region (B). Moreover, the region except for the light emitting region is shielded with the black portion of the color filter, that is, shielded with a shielding section **31a**. It should be noted that the light shielding section **31a** is composed of a metal film (chromium and the like) or an organic film containing a black pigment.

In the present invention, a circularly polarized plate is not required since the color filters are provided.

Moreover, FIG. 1B is a sectional view taken on chain line B-B' shown in FIG. 2. Also in FIG. 1B, both ends of **11a-11c** and their interval are covered with the inorganic insulating matter **14**. Here, an example in which the EL layer **17** for emitting red color is common is shown, but it is not limited to that. The EL layer may be formed per each pixel for emitting the same color. Moreover, in FIG. 1, the protective film **32b** for enhancing the reliability of the light emitting device is formed. The protective film **32b** is an insulation film whose major component is silicon nitride or silicon oxynitride, obtained by a sputtering method. Moreover, in FIG. 1, in order to make the emitted light pass through the protective film **32b**, it is preferable that the film thickness of the protective film **32b** is made as thinner as possible. Furthermore, the protective film **32a** containing hydrogen is formed before the protective film **32b** is formed for the purpose of enhancing the reliability of light emitting device. The drawbacks of the organic compound layers **17-19** are terminated by forming the protective film **32a** containing hydrogen before the protective film **32b** is formed. The foregoing film **32a** containing hydrogen may be made a thin film whose major component is carbon or a silicon nitride film. As a method of forming the film **32a** containing hydrogen, in the temperature range, for example, in the range from room temperature to 100° C. or less where the foregoing organic compound layer is durable, it is formed by plasma CVD method or by a sputtering method. It should be noted that in FIG. 1, the film **32a** containing hydrogen is considered as a layer located beneath the protective film. Moreover, the above-described film **32a** containing hydrogen can be made as a buffer layer that relaxes the film stress of the protective film **32b**.

Moreover, the present invention is, needless to say, not limited to the configuration shown in FIG. 1C. The examples

## 12

in which one portion of the configuration is different from the configuration of FIG. 1C are shown in FIGS. 10A to 10D. It should be noted that for the simplification, in FIGS. 10A to 10D, the same reference numerals are used for the same portions with those in FIG. 1. FIG. 1C is an example in which an electrode composed of the same material (transparent electrode) with that of the cathode in the terminal section, while FIG. 10A is an example in which FPC is contacted with the electrode (upper layer is W film and the lower layer is TaN film) composed of the same material with that of the gate electrode of TFT.

Moreover, FIG. 10B is an example in which the FPC is connected with the electrode **10** composed of the same material with that of the pixel electrode (anode). It should be noted that this electrode **10** is provided on the electrode (upper layer is W film and the lower layer is TaN film) whose material is the same with that of the gate electrode of TFT and contacted with the electrode.

Moreover, FIG. 10C is an example in which the FPC is contacted with an electrode composed of the same material (transparent electrode) with the cathode **20** formed on the electrode **10** composed of the same material with the pixel electrode (anode) provided on the drawing wiring of the TFT (wiring that TiN film, Al film, TiN film in turn are laminated).

Moreover, FIG. 10D is an example in which the FPC is contacted with an electrode composed of the same material (transparent electrode) with the cathode **20** formed on the drawing wiring (wiring that TiN film, Al film, TiN film in turn are laminated). Moreover, an example whose configuration is partially different from the configuration of FIG. 1 is shown in FIG. 8. It should be noted that for simplification, in FIG. 8, the same reference numeral is used for the portion which is the same with that of FIG. 1. As shown in FIG. 8A, there is an example in which an insulator **24** (also reference to as bank, embankment or barrier) composed of an organic resin covered with the inorganic insulation film **14** is provided between the light emitting region **10R** and the light emitting region **10G**, and between the light emitting region **10G** and the light emitting region **10B**. When such an insulator **24** is formed, it is necessarily difficult to make the interval between the light emitting region **10G** and the light emitting region **10B** narrow depending on the patterning precision. In many cases, although the embankment is provided around each pixel, in FIG. 8, a configuration in which the embankment is provided per each pixel row is made.

Moreover, an example in which the configuration is partially different from that of FIG. 8. For simplification, in FIG. 9, the same reference numeral is used for the same portions as in FIG. 8 and FIG. 1. In FIG. 9A, an example in which the region of the laminated section is larger than that of FIG. 8A is shown, and in FIG. 9B, it does not have the laminated section, and an example in which the ends of the organic compound layer is disposed on the insulator **24** is shown. In this way, the location of the ends of the organic compound layer is not particularly limited if it is disposed on the insulator **24**.

In FIG. 1, since the insulator **24** composed of an organic resin is not provided, comparing to FIG. 8, the interval between the respective light emitting regions can be narrowed, and a high definition light emitting device can be realized.

## Embodiment 2

Now, a film containing hydrogen and a protective film will be described with reference to FIG. 3 and FIG. 4 below.

13

A light emitting mechanism of an organic EL depends upon the mechanism in which electron and hole is implanted from the exterior and the light emitting center is excited by those recombination energy. A structure of an organic EL is typically a three-layer structure, but here the structure will be described below using a two layer structure (electron transport layer, hole transport layer). In FIG. 3A, the energy band diagram of the EL element in which an organic compound layer having a two layer structure is sandwiched by a cathode and an anode is shown in FIG. 3A.

FIG. 3A shows an ideal energy band diagram. It should be noted that here, a light emitting mechanism will be described below by exemplifying an example in which an ITO is used as an anode, and MgAg is used in the cathode.

When the direct current voltage is applied from the exterior with respect to the EL element having the above-described two layer structure, a hole is implanted from an ITO electrode which is an anode, transported to the interface with the organic compound layer, and implanted into the organic compound layer. On the other hand, an electron is implanted from the MgAg electrode, transported within the organic compound layer, reaches nearby the interface, and recombined with the hole on the light emitting molecule. As a result, the excitation state of the light emitting molecule is generated, and the emission resembling to the fluorescence spectrum of the molecule is generated.

However, it is expected that the energy band diagram is actually shown in FIG. 3B.

It is considered that in the organic compound layer, numerous drawbacks exist, as shown in FIG. 3B, a level is formed. In the case where an electron is trapped in this drawback, the light emitting efficiency is lowered. In the case where it is trapped, it is deactivated through a variety of pathways, for example, it becomes a thermal quenching or an emission of infrared light. The causing factor of the drawback is considered that it is because a dangling bond or unstable bond exists. For example, in the case where a material constituting the organic compound layer contains carbon atoms and a dangling bond of the carbon atom also makes the EL element continuously emit the light, it is considered that the heat due to the emission breaks the unstable bond, then dangling bond may be generated, the drawbacks may be increased by chemical reaction being generated to cause aging degradation.

Then, the present inventor finds that this drawbacks is neutralized with hydrogen (hydrogen radical), and an inter-band transition is caused more efficiently to increase brightness, and further the degradation is prevented. As a means of the hydrogen neutralization, in forming a hydrogen containing film covering the EL element, a method of implanting hydrogen into an organic compound layer, or a method of generating plasma in a hydrogen atmosphere, or a method of addition by ion doping or ion implantation are enumerated.

Moreover, in the case where an EL element emits and an unstable bond in the organic compound layer is broken and a dangling bond is generated, if a film containing hydrogen is disposed nearby the organic compound layer, then the unpaired bond generated can be terminated with hydrogen and the deterioration can be suppressed. It should be noted that hydrogen is an atom easily diffused even at a comparatively low temperature.

Hereinafter, a representative example in which a film containing hydrogen covering the EL element is formed is shown in FIG. 4. FIG. 4A is a schematic diagram showing an example of a laminated structure of an EL element. In FIG. 4A, the reference numeral 200 denotes an anode (or cathode), the reference numeral 201 denotes an EL layer, the reference numeral 202 denotes a cathode (or anode), the reference

14

numeral 203 denotes a DLC film containing hydrogen, the reference numeral 204 denotes a protective film. Moreover, in the case where the emission is made in the direction of the arrow in the FIG. 4A (in the case where the emission is made pass through the anode 202), it is preferable that for the reference numeral 202, a conductive material having a translucent property or a very thin metal film (alloy such as MgAg, MgIn, AlLi, CaN, or a film formed using an element belonging to 1 Group or 2 Group of the periodic table and aluminum by co-vapor deposition method), or the laminated layer thereof is used.

For the protective film 204, an insulation film whose major component is silicon nitride or oxynitride silicon obtained by a sputtering method (DC method or RF method) may be used. If it is formed with atmosphere containing nitrogen and argon using a silicon target, silicon nitride film is obtained. Moreover, a silicon nitride target may be also used. Moreover, the protective film 204 may be formed using a film formation unit using a remote plasma. Moreover, in the case where the emitted light is made pass through the protective film, it is preferable that the film thickness of the protective film is made as thin as possible. Moreover, the DLC film 203 containing hydrogen contains 70-95 atom % of carbon and 5-30 atom of hydrogen, very hard and excellent in insulating property. The DLC film containing hydrogen can be formed by a plasma CVD method (representatively, RF plasma CVD method, microwave CVD method, electron cyclotron resonance (ECR) CVD method and the like), a sputtering method and the like. As a method of forming the DLC film 203 containing hydrogen, there is a method in which the DLC film is formed in the temperature range where the foregoing organic compound layer is durable, for example, in the range from room temperature to 100° C. or less. For the reactant gas used for forming a film in the case where plasma is generated, hydrogen gas and hydrocarbon based gas (for example, CH<sub>4</sub>, C<sub>2</sub>H<sub>2</sub>, C<sub>6</sub>H<sub>6</sub> and the like) may be used.

The drawback in an organic compound layer can be terminated with hydrogen by diffusing hydrogen from the above-described DLC film containing hydrogen by means of performing the heating treatment in a temperature range where the organic compound layer is durable or by means of utilizing the heat generation generated at the time when the light emitting element emits the light. Once the drawback in the organic compound layer is terminated with hydrogen, the reliability and the brightness are enhanced as a light emitting device. Moreover, when the above-described DLC film containing hydrogen is formed in a film, the drawback in the organic compound layer may be also terminated with hydrogen which has been made plasmatic. Moreover, the protective layer for covering and forming the DLC film containing hydrogen blocks hydrogen diffusing to the protective layer side and efficiently diffusing hydrogen into an organic compound layer and plays a role for terminating the drawback in the organic compound layer with hydrogen. It should be noted that the above-described DLC film containing hydrogen can be functioned as a protective film of a light emitting element. Furthermore, the above-described DLC film containing hydrogen can be functioned as a buffer layer, in the case where a silicon nitride film is formed in a state where it is contacted with a film composed of a transparent conductive film by a sputtering method, it is feared that impurities (In, Sn, Zn and the like) contained in the transparent conductive film is contaminated into the silicon nitride film. However, the impurities contamination into the silicon nitride film can be prevented by forming the above-described DLC film containing hydrogen which is to be a buffer layer between two films. Due to the above-described constitution, buffer layer is



15

formed and thus contamination of impurities (In, Sn and the like) from the transparent conductive film can be prevented, and an excellent protective film without any impurities can be formed.

By thus configuring, the reliability and the brightness can be enhanced as well as the light emitting element is protected. Moreover, FIG. 4B is a schematic diagram showing another example of a laminated structure of an EL element. In FIG. 4B, the reference numeral 300 denotes an anode (or cathode), the reference numeral 301 denotes an EL layer, the reference numeral 302 denotes a cathode (or anode), the reference numeral 303 denotes a silicon nitride film containing hydrogen, the reference numeral 304 denotes a protective film. Moreover, in the case where the emission is made in the direction of the arrow in the FIG. 4B (in the case where the emission is made pass through the anode 302), it is preferable that for the reference numeral 302, a conductive material having a translucent property or a very thin metal film (MgAg), or the laminated layer thereof is used.

For the protective film 304, an insulation film whose major component is silicon nitride or silicon oxynitride obtained by a sputtering method (DC method or RF method) may be used. If it is formed under the atmosphere containing nitrogen and argon using a silicon target, silicon nitride film is obtained. Moreover, a silicon nitride target may be used. And, the protective film 304 may be formed using a film formation unit using a remote plasma. Moreover, in the case where the emitted light is made pass through the protective film, it is preferable that the film thickness of the protective film is made as thin as possible.

Moreover, the silicon nitride film 303 containing hydrogen can be formed by a plasma CVD method (representatively, RF plasma CVD method, microwave CVD method, electron cyclotron resonance (ECR) CVD method and the like), a sputtering method and the like. As a method of forming the silicon nitride film 303 containing hydrogen, there is a method in which the film is formed in the temperature range where the foregoing organic compound layer is durable, for example, in the range from room temperature to 100° C. or less.

As a method of forming the silicon nitride film 303 containing hydrogen, in the case where a plasma CVD method is used, for the reactant gas, gas containing nitrogen (nitrogen oxide based gas represented by  $N_2$ ,  $NH_3NO_x$  or the like) and hydrogen silicide based gas (for example, silane ( $SiH_4$ ) and disilane and trisilane or the like) may be used.

As a method of forming the silicon nitride film 303 containing hydrogen, in the case where a sputtering method is used, a silicon target is used, and if it is formed under the atmosphere containing hydrogen, nitrogen and argon, a silicon nitride film containing hydrogen can be obtained. Moreover, a silicon nitride target may be used.

The drawback in an organic compound layer can be terminated with hydrogen by diffusing hydrogen from the above-described silicon nitride film containing hydrogen by means of performing the heating treatment in a temperature range where the organic compound layer is durable or by means of utilizing the heat generation generated at the time when the light emitting element emits the light. Once the drawback in the organic compound layer, dangling bond is terminated with hydrogen, the reliability and the brightness are enhanced as a light emitting device. Moreover, when the above-described silicon nitride film containing hydrogen is formed in a film, the drawback in the organic compound layer may be also terminated with hydrogen which has been made plas-  
matic. Moreover, the protective layer for covering and forming the silicon nitride film containing hydrogen blocks hydro-

16

gen diffusing to the protective layer side and efficiently diffusing hydrogen into an organic compound layer and plays a role for terminating the drawback in the organic compound layer with hydrogen. It should be noted that the above-described silicon nitride film containing hydrogen could be functioned as a protective film of a light emitting element.

Furthermore, the above-described silicon nitride film containing hydrogen can be functioned as a buffer layer, in the case where the silicon nitride film is formed in a state where it is contacted with a film composed of a transparent conductive film by a sputtering method, it is feared that impurities (In, Sn, Zn and the like) contained in the transparent conductive film is contaminated into the silicon nitride film. However, the impurities contamination into the silicon nitride film can be prevented by forming the above-described silicon nitride film containing hydrogen which is to be a buffer layer between two films. The contamination of impurities (In, Sn and the like) from the transparent conductive film is prevented and an excellent protective film without any impurities can be formed by forming the buffer layer according to the above-described configuration.

By thus configuring, the reliability and the brightness can be enhanced as well as the light emitting element is protected. Moreover, FIG. 4C is a schematic diagram showing another example of a laminated structure of an EL element. In FIG. 4C, the reference numeral 400 denotes an anode (or cathode), the reference numeral 401 denotes an EL layer, the reference numeral 402 denotes a cathode (or anode), the reference numeral 403 denotes a film containing hydrogen, the reference numeral 404 denotes a protective film. Moreover, in the case where the emission is made in the direction of the arrow in FIG. 4C (in the case where the emission is made pass through the cathode 402), it is preferable that for the reference numeral 402, a conductive material having a translucent property is used.

For the protective film 404, an insulation film whose major component is silicon nitride or silicon oxynitride obtained by a sputtering method (DC method or RF method) may be used. If it is formed under the atmosphere containing nitrogen and argon using a silicon target, silicon nitride film is obtained. Moreover, the protective film 404 may be also formed using a film formation unit using remote plasma. Moreover, in the case where the emitted light is made pass through the protective film, it is preferable that the film thickness of the protective film is made as thin as possible.

Moreover, the film 403 containing hydrogen can be formed using reactant gas containing hydrogen by a plasma CVD method (representatively, RF plasma CVD method, microwave CVD method, electron cyclotron resonance (ECR) CVD method and the like), a sputtering method and the like.

As for the film 403 containing hydrogen, it is made a DLC film, a silicon nitride film, a silicon oxynitride film, a silicon oxide film or a laminated film thereof.

As a method of forming the film 403 containing hydrogen, there is a method in which the film is formed in the temperature range where the foregoing organic compound layer is durable, for example, in the range from room temperature to 100° C. or less.

The drawback in an organic compound layer can be terminated with hydrogen by diffusing hydrogen from the above-described silicon nitride film containing hydrogen by means of performing the heating treatment in a temperature range where the organic compound layer is durable or by means of utilizing the heat generation generating at the time when the light emitting element emits the light. Once the drawback in the organic compound layer, representatively, dangling bond is terminated with hydrogen, the reliability and the brightness

17

are enhanced as a light emitting device. Moreover, when the above-described silicon nitride film containing hydrogen is formed, the drawback in the organic compound layer may be also terminated with hydrogen which has been made plas-

matic. Moreover, the protective layer for covering and forming the silicon nitride film containing hydrogen blocks hydrogen diffusing to the protective layer side and efficiently diffuses hydrogen into an organic compound layer and plays a role for terminating the drawback in the organic compound layer with hydrogen.

Furthermore, the above-described film **403** containing hydrogen can be functioned as a buffer layer of the protective film **404**, and in the case where a protective film composed of a silicon nitride film is formed in a state where it is in contact with a film composed of a transparent conductive film by a sputtering method, it is feared that impurities (In, Sn, Zn and the like) contained in the transparent conductive film are contaminated into the silicon nitride film, but the impurities contamination into the silicon nitride film can be prevented by forming the above-described silicon nitride film containing hydrogen which is to be a buffer layer between two films. The contamination of impurities (In, Sn and the like) from the transparent conductive film is prevented and an excellent protective film without any impurities can be formed by forming the buffer layer according to the above-described configuration.

By thus configuring, the reliability and the brightness can be enhanced as well as the light emitting element is protected. Moreover, although in FIGS. **4A** to **4C**, an example in which a film containing hydrogen is made a monolayer is shown, but it may be also a laminated layer of a silicon nitride film containing hydrogen and a DLC film containing hydrogen or a laminated layer of these 3 layers or more.

Moreover, the present embodiment can be applied to not only an active matrix type display device, but also a passive type display device.

Moreover, the present embodiment can be freely combined with Embodiment 1.

#### Embodiment 3

Now, an example whose configuration is partially different from the configuration of FIG. **1** is shown in FIG. **5**. It should be noted that for simplification, in FIG. **5**, the same reference numeral is used for the portion which is the same with that of FIG. **1**. In FIG. **5A**, an example in which it is made a structure where the impurities from the color filters **31a-31d** are prevented from diffusing by covering the sealing substrate **30** with the film **35** whose major component is silicon nitride is exemplified. Moreover, FIG. **5B** is a diagram corresponding to FIG. **1C**, but in order to enhance the adhesion of the sealing member **33**, the convex portion **24** is formed with the same material with those of the color filters **31a-31d**.

Moreover, the present Embodiment can be freely combined with Embodiment 1 or Embodiment 2.

#### Embodiment 4

Now, an example of a fabrication unit (multi-chamber method) by which the laminated structure of FIG. **4A**, the laminated structure of FIG. **4B** and the laminated structure of FIG. **4C** can be separately made is shown in FIG. **6**.

In FIG. **6**, the reference numerals and characters **100a-100k**, **100m-100v** denote gates, the reference numerals **101**, **119** denote delivery chambers, the reference numerals and characters **102**, **104a**, **107**, **108**, **111**, and **114** denote carrier chambers, the reference numerals and characters **105**, **106R**,

18

**106B**, **106G**, **106H**, **109**, **110**, **112** and **113** denote film forming chambers, the reference numeral **103** denotes a pretreatment chamber, the reference numerals and characters **117a**, **117b** denote sealing substrate loading chambers, the reference numeral **115** denotes a dispenser chamber, the reference numeral **116** denotes a sealing chamber, the reference numeral **118** denotes a ultraviolet ray irradiation chamber, and the reference numeral **120** denotes a substrate inversion chamber. Hereinafter, the procedure by which the substrate on which the TFT has been previously provided is carried into the fabrication unit shown in FIG. **6**, the laminated structure shown in FIG. **4A** is formed will be described.

First, the substrate on which the TFT and the anode **200** are provided is set in the delivery chamber **101**. Subsequently, it is transported to the carrier chamber **102** connected to the delivery chamber **101**. It is preferable that after moisture and oxygen are previously vacuum-pumped so that the moisture and oxygen do not exist within the carrier chamber, an inert gas is introduced and set at the atmospheric pressure.

Moreover, the carrier chamber **102** is connected to a vacuum pumping treatment chamber for vacuum-pumping within the carrier chamber. The vacuum pumping treatment chamber is equipped with a magnetic levitated type turbo molecular pump, cryopump, or dry pump. By utilizing this, it is possible to make the ultimate pressure of the carrier chamber be  $10^{-5}$ - $10^{-6}$  Pa, and further, reverse diffusion of impurities from the pump side and exhaust system can be controlled. In order to prevent impurities from being introduced into the interior of the device, for a gas to be introduced, an inert gas such as nitrogen and rare gas and the like are used. For these gases introduced into the device, gases highly purified by a gas purifier prior to the introduction into the interior of the device are used. Therefore, it is required that a gas purifier is implemented so that the gas is introduced into the film forming chamber following the high purification of the gas. Since by utilizing this, oxygen, moisture and the other impurities contained in the gas can be previously removed, it can prevent the impurities from being introduced into the interior of the device.

Moreover, in order to remove the moisture and the other gases contained in the substrate, it is preferable that the annealing for degassing is carried out under the vacuum, and it is transported to the pretreatment chamber **103** connected to the carrier chamber **102** and the annealing may be carried out there. Furthermore, if it is necessary to clean the surface of the anode, it is transported to the pretreatment chamber **103** connected to the carrier chamber **102**, then, the cleaning may be carried out there.

Moreover, if it is necessary, an organic compound layer composed of a polymer molecule may be formed on the whole surface of the anode. In the fabrication unit of FIG. **6**, the film forming chamber **105** is provided for forming the organic compound layer composed of the polymer molecule. In the case where it is formed by a spin coat method, an ink jet method and a spray method, the surface of the substrate to be film-formed is set under the atmospheric pressure in the overhead position. The substrate is appropriately rotated inversely in the substrate inversion chamber **120** provided between the film forming chamber **105** and the carrier chamber **102**. Moreover, it is preferable that after the film formation has been carried out using the solution, it is transported to the pretreatment chamber **103**, where the heating treatment is carried out under the vacuum and the solvent (water and the like) is vaporized.

Subsequently, without being in contact with the atmosphere, after the substrate **104c** has been transported to the carrier chamber **104** from the carrier chamber **102**, it is trans-

19

ported to the film forming chamber **106R** by the carrier mechanism **104b**, and an EL layer which emits the red color is appropriately formed on the anode **200**. Here, an example in which it is formed by vapor deposition is shown. The surface to be film-formed of the substrate is set in an under-head position in the substrate inversion chamber **120** and carried into the film forming chamber **106R**. It should be noted that it is preferable that it has been previously vacuum-pumped within the film forming chamber prior to the carrying-in of the substrate.

For example, the vapor deposition is carried out in the film forming chamber **106R** which has been vacuum-pumped to the degree of vacuum of  $5 \times 10^{-3}$  Torr (0.665 Pa) or less, and preferably, to the degree of vacuum of  $10^{-4}$ - $10^{-6}$  Pa. Upon the vapor deposition, the organic compound has been previously vaporized by the resistance heating, it flies away toward the direction of the substrate by the shutter (not shown) being opened at the time when the vapor deposition is carried out. An organic compound vaporized flies away upwardly, it is vapor deposited on the substrate through the opening (not shown) provided on the metal mask (not shown). It should be noted that upon the vapor deposition, the temperature of the substrate ( $T_1$ ) is made in the range from 50 to 200° C., preferably, in the range from 65 to 150° C. by means of heating the substrate.

In order to make it be the full color specification, in the case where three kinds of EL layers are formed, after it has been formed in the film forming chamber **106R**, the film formation may be in turn carried out in the respective film forming chamber **106G** and **106B**.

When the desired EL layer **201** has been obtained on the anode **200**, subsequently, after the substrate is transported to the carrier chamber **107** from the carrier chamber **104** without being in contact with the atmosphere, and further, the substrate is transported to the carrier chamber **108** from the carrier chamber **107** without being in contact with the atmosphere.

Subsequently, after it has been transported to the film forming chamber **110** by the carrier mechanism provided within the carrier chamber **108**, and a thin metal layer has been formed on the EL layer **201**, it is transported to the film forming chamber **109** and the transparent conductive film is formed, the cathode **202** composed of the laminated layer of the thin metal layer and the transparent conductive film is appropriately formed. Here, the film forming chamber **110** is made a vapor deposition device equipped with a vapor deposition source of Mg and Ag, and the film forming chamber **109** is made a sputtering device having at least a target comprising a transparent conductive material.

Subsequently, it is transported to the film forming chamber **112** by the carrier mechanism provided within the carrier chamber **108**, the DLC film **203** containing hydrogen in the temperature range where the organic compound layer is durable is formed. Here, the film forming chamber **112** is equipped with a plasma CVD device, and as for the reactant gas used for forming a film, a DLC film is formed using hydrogen gas and hydrocarbon based gas (for example,  $\text{CH}_4$ ,  $\text{C}_2\text{H}_2$ ,  $\text{C}_6\text{H}_6$  and the like). Moreover, instead of the DLC film, a silicon nitride film containing hydrogen is formed, and the structure shown in FIG. 4B may be formed. It should be noted that the structure is not particularly limited if it is equipped with the means for generating hydrogen radical, and at the time when the above-described DLC film containing hydrogen is formed, the drawback in the organic compound layer is terminated with hydrogen which has been made plasmatic.

Subsequently, it is transported to the film forming chamber **113** from the carrier chamber **108** and the protective film **204**

20

is formed on the DLC film **203** containing hydrogen. Here, it is made a sputtering device equipped with a target composed of silicon or a target composed of silicon nitride. A silicon nitride film can be formed by making the film forming chamber under the nitrogen atmosphere or by making it under the atmosphere containing nitrogen and argon.

In the above-described steps, the laminated structure shown in FIG. 4A, that is, a light emitting element covered by the protective film and the DLC film containing hydrogen is formed on the substrate.

Subsequently, the substrate on which the light emitting element is formed is transported to the carrier chamber **111** from the carrier chamber **108** without being in contact with the atmosphere and further, it is transported from the carrier chamber **111** into the carrier chamber **114**.

Subsequently, the substrate on which the light emitting element is formed is transported from the carrier chamber **114** to the sealing chamber **116**. It should be noted that it is preferable that the sealing substrate on which a sealing member is provided has been previously prepared for in the sealing chamber **116**.

The sealing substrate is set in the sealing substrate loading chambers **117a**, **117b** from the exterior. It should be noted that it is preferable that the annealing has been previously carried out under the vacuum in order to remove the impurities such as water or the like, for example, the annealing is carried out within the sealing substrate loading chambers **117a**, **117b**. Then, in the case where the seal member is formed on the sealing substrate, after it is set at the atmospheric pressure in the carrier chamber **108**, the sealing substrate is transported from the sealing substrate loading chamber to the dispenser chamber **115**, a seal member for pasting it with the substrate on which the light emitting element is provided is formed, the sealing substrate on which the sealing member has been formed is transported to the sealing chamber **116**.

Subsequently, in order to degas the substrate on which the light emitting element has been provided, after the annealing has been carried out under the vacuum or under the inert atmosphere, the sealing substrate on which the sealing member has been provided and the substrate on which the light emitting element has been formed are pasted together. Moreover, hydrogen or an inert gas is filled in the space sealed. It should be noted that here, an example in which the sealing member has been formed on the sealing substrate is shown, but it is not particularly limited to that, and the sealing member may be formed on the substrate on which the light emitting element has been formed.

Subsequently, a pair of substrates pasted together is transported from the carrier chamber **114** to the ultraviolet ray irradiation chamber **118**. Subsequently, the ultraviolet (UV) ray is irradiated in the ultraviolet ray irradiation chamber **118** and the sealing member is hardened. It should be noted that here, using the ultraviolet ray hardened resin as a sealing member, but it is not particularly limited to that if it is adhesive member. Subsequently, it is transported from the carrier chamber **114** to the delivery chamber **119** and it is unloaded.

As described above up to here, since the light emitting element is not exposed to the ambient air until the light emitting element is completely enclosed in the sealed space by using the fabrication unit shown in FIG. 6, it is possible to prepare a highly reliable light emitting device. It should be noted that in the carrier chambers **102**, **114**, the vacuum and the atmospheric pressure are alternately changed and this procedure is repeated, but the vacuum is continuously maintained in the carrier chambers **104a** and **108**. It should be noted that it is possible to make it a film forming device of in-line method.

Hereinafter, the procedure by which the substrate on which the TFT and anode have been previously provided is carried into the fabrication unit shown in FIG. 6, and the laminated structure shown in FIG. 4C is formed is described.

First, the substrate on which the TFT and the anode **400** are provided is set in the delivery chamber **101**. Subsequently, it is transported to the carrier chamber **102** connected to the delivery chamber **101**. It is preferable that after it has been vacuum-pumped so that the moisture and oxygen do not exist as far as possible within the carrier chamber, an inert gas is introduced and set at the atmospheric pressure. For a material for forming the anode **400**, a transparent conductive material is used, indium tin compound or zinc oxide and the like can be used. Subsequently, it is carried into the pretreatment chamber **103** connected to the carrier chamber **102**. In this pretreatment chamber, the cleaning, the oxide treatment, heating treatment and the like of the surface of the anode may be carried out. As the cleaning of the surface of the anode, the ultraviolet ray irradiation under the vacuum, or oxygen plasma treatment is carried out, thereby cleaning the surface of the anode. Moreover, as an oxide treatment, the ultraviolet ray may be irradiated under the atmosphere containing oxygen while it is heated in the range from 100 to 120° C., and in the case where the anode is an oxide like an ITO, it is effective. Moreover, as a heating treatment, the heating may be carried out at the heating temperature at 50° C. or more where the substrate is durable under the vacuum, preferably, the heating may be carried out at 65-150° C., and the impurities such as oxygen, moisture and the like attached to the substrate and impurities such as oxygen, moisture and the like in the film formed on the substrate are removed. Since particularly, an EL material is easily subjected to the deterioration by the impurities such as oxygen, water and the like, the heating under the vacuum prior to the vapor deposition is effective.

If it is necessary, after the substrate **104c** has transported from the carrier chamber **102** into the carrier chamber **104** without being in contact with the atmosphere, it is transported to the film forming chamber **105** by the carrier mechanism **104b**, and a hole transport layer, a hole implantation layer or the like which is one layer of the EL layer is appropriately laminated and formed on the anode **400**. Here, an example in which it is formed by vapor deposition is shown. The surface to be film-formed of the substrate is set in an underhead position in the film forming chamber **105**. It should be noted that it is preferable that it has been previously vacuum-pumped within the film forming chamber prior to the carrying-in of the substrate.

Subsequently, it is transported to the film forming chamber **106R**, and an EL layer which emits red color is appropriately formed on the anode **400**. Here, an example in which it is formed by a vapor deposition method is shown. The surface to be film formed of the substrate is set in an underhead position in the substrate inversion chamber **120** and carried into the film forming chamber **106R**. It should be noted that it is preferable that it has been previously vacuum-pumped within the film forming chamber prior to the carrying-in of the substrate.

For example, the vapor deposition is carried out in the film forming chamber **106R** which has been vacuum-pumped to the degree of vacuum of  $5 \times 10^{-3}$  Torr (0.665 Pa) or less, and preferably, to the degree of vacuum of  $10^{-4}$ - $10^{-6}$  Pa. Upon the vapor deposition, the organic compound has been previously vaporized by performing the resistance heating, it flies away toward the direction of the substrate by the shutter (not shown) being opened at the time when the vapor deposition is carried out. An organic compound vaporized flies away upward, it is vapor deposited on the substrate through the

opening (not shown) provided on the metal mask (not shown). It should be noted that upon the vapor deposition, the temperature of the substrate ( $T_s$ ) is made in the range from 50 to 200° C., preferably, in the range from 65 to 150° C. by means of heating the substrate.

In order to make it be the full color specification, in the case where three kinds of EL layers are formed, after it has been formed in the film forming chamber **106R**, the film formation may be in turn carried out in the respective film forming chamber **106G** and **106B**.

When the desired EL layer **401** has been obtained on the anode **400**, subsequently, after the substrate is transported to the carrier chamber **107** from the carrier chamber **104** without being in contact with the atmosphere, and further, the substrate is transported to the carrier chamber **108** from the carrier chamber **107** without being in contact with the atmosphere.

Moreover, if it is necessary, poly (ethylenedioxythiophene)/poly (styrenesulfonic acid) aqueous solution (PEDOT/PSS) which acts as a hole implantation layer may be formed on the whole surface prior to the formation of the cathode. In the fabrication unit shown in FIG. 6, the film forming chamber **105** for forming the organic compound layer composed of the polymer molecule is provided. In the case where it is formed by a spin coat method, an ink jet method and a spray method, the surface of the substrate to be film-formed is set under the atmospheric pressure in the over-head position. The substrate is appropriately inversed in the substrate inversion chamber **120** provided between the film forming chamber **105** and the carrier chamber **102**. Moreover, it is preferable that after the film formation has been carried out using the aqueous solution, it is transported to the pretreatment chamber **103**, where the heating treatment is carried out under the vacuum and the moisture is vaporized.

Subsequently, it is transported to the film forming chamber **110** by the transportation mechanism provided within the carrier chamber **108** and the cathode **402** composed of a metal layer is formed on the EL layer **401**. Here, the film forming chamber **110** is made a vapor deposition device in which a vapor deposition source is equipped with AlLi.

Subsequently, it is transported to the film forming chamber **112** by the carrier mechanism provided within the carrier chamber **108**, and the film **403** containing hydrogen is formed in the temperature range where the organic compound layer is durable. Here, the film forming chamber **112** is equipped with a plasma CVD device, and as for the reactant gas used for forming a film, appropriately using hydrogen gas and hydrocarbon based gas or a hydrogen silicide based gas, a film composed of a DLC film, a silicon nitride film, silicon oxynitride film, a silicon oxide film or a laminated layer thereof is formed. It should be noted that it is not particularly limited if it is equipped with means for generating hydrogen radical, at the time when the above-described film containing hydrogen is formed, the drawback in the organic compound layer is terminated with hydrogen which has been made plasmatic.

Subsequently, without being contact with the atmosphere it is transported to the film forming chamber **113** from the carrier chamber **108** and the protective film **404** is formed on the film **403** containing hydrogen. Here, in the film forming chamber **113** it is made a sputtering device equipped with a target composed of silicon or a target composed of silicon nitride. A silicon nitride film can be formed by making the film forming chamber under the nitrogen atmosphere or by making it under the atmosphere containing nitrogen and argon.

In the above-described steps, the laminated structure shown in FIG. 4C, that is, a light emitting element covered by

## 23

the protective film and the film containing hydrogen is formed on the substrate. Since the following steps are the same with the procedure by which the laminated structure shown in FIG. 4A is formed, here, the description is omitted.

In this way, if the fabrication unit shown in FIG. 6 is used, the laminated structures shown in FIGS. 4A to 4C can be separately fabricated.

Moreover, the fabrication unit which is partially different from that shown in FIG. 6 is shown in FIG. 7.

In FIG. 6, there is an example in which only one film forming chamber for forming a film by a spin coat method, an ink jet method and a spray method is provided. However, the fabrication unit shown in FIG. 7 is an example with which three film forming chambers for forming a film by a spin coat method, an ink jet method and a spray method are equipped. For example, in order to make it full color specification, in the case where three kinds of EL layers are formed by a spin coat method, a ink jet method and a spray method, after it has been formed in the film forming chamber 121a, the film formation may be in turn carried out in the respective film forming chambers 121b and 121c. Moreover, it is preferable that after the film formation has been carried out using a spin coat method, an ink jet method, and a spray method, it is transformed to the pretreatment chamber 103, where the heating treatment is carried out under the vacuum and the moisture is vaporized. Moreover, the present Embodiment can be freely combined with Embodiment 1, Embodiment 2 or Embodiment 3.

## Embodiment 5

Now, an example whose configuration is partially different from the configuration of FIG. 1 is shown in FIG. 11. It should be noted that for simplification, in FIG. 11, the same reference numeral is used for the portion which is the same with that of FIG. 1. In FIG. 11A, there is provided an example in which an auxiliary electrode 23 is formed on the inorganic insulation film 14. This auxiliary electrode 23 functions as one portion of a cathode (or anode). Since the resistance of the cathode 20 composed of a transparent conductive electrode is comparatively high, it is difficult to make it a large screen, but a cathode (or anode) as a whole can be made low resistance. In addition, the transparent conductive film can be made thinner.

Furthermore, it is connected to the wirings and electrodes of the lower layers through this auxiliary electrode 23. This auxiliary electrode 23 may be formed in a film and patterned prior to the formation of an EL layer. The auxiliary electrode 23 may be formed with an element selected from W, WSi<sub>x</sub>, Al, Ti, Mo, Cu, Ta, Cr, Ni, Mo, or poly-Si which has been doped with impurities for conferring the conductive type by utilizing a sputtering method, a vapor deposition method or the like or an alloy material whose major component is the foregoing elements or a film whose major component is a compound material, or a laminated film thereof. In this way, if the transparent conductive film is formed while being in contact with and superimposed on the auxiliary electrode 23 which has been made contacted with the electrode of the lower layer, the drawing of the cathode can be realized. It should be noted that FIG. 11C is a sectional view taken on chain line C-C' shown in FIG. 2. Moreover, in FIG. 11C, it is shown that the electrodes shown in dotted line are electrically connected each other. Moreover, in the terminal portion, the electrode of the terminal is formed with the same materials with those of the cathode 20.

Moreover, the present Embodiment can be freely combined with Embodiment 1, Embodiment 2, Embodiment 3 or Embodiment 4.

## 24

The present invention comprising the above-described configurations will be further described in detail with reference to examples shown in the following.

## EXAMPLES

## Example 1

In this example, an active matrix type light emitting device manufactured on an insulating film will be described. FIG. 12 is a cross sectional view of the active matrix type light emitting device. As an active element, a thin film transistor (hereafter referred to as a TFT) is used here, a MOS transistor may also be used.

A top gate TFT (specifically a planar TFT) is shown as an example of a TFT, a bottom gate TFT (typically inversely staggered TFT) may also be used.

In this example, a substrate 800 is used, which is made of barium borosilicate glass or alumino borosilicate glass, a quartz substrate, a silicon substrate, a metal substrate, or stainless substrate forming an insulating film on the surface may be used. A plastic substrate having heat resistance enduring a treatment temperature of this example also may be used, and further a flexible substrate may be used.

First, a silicon oxynitride film is formed as a lower layer 801 of a base insulating film on a heat-resistant glass substrate (the substrate 800) with a thickness of 0.7 mm by plasma CVD at a temperature of 400° C. using SiH<sub>4</sub>, NH<sub>3</sub>, and N<sub>2</sub>O as material gas (the composition ratio of the silicon oxynitride film: Si=32%, O=27%, N=24%, H=17%). The silicon oxynitride film has a thickness of 50 nm (preferably 10 to 200 nm). The surface of the film is washed with ozone water and then an oxide film on the surface is removed by diluted fluoric acid (diluted down to 1/100). Next, a silicon oxynitride film is formed as an upper layer 802 of the base insulating film by plasma CVD at a temperature of 400° C. using SiH<sub>4</sub> and N<sub>2</sub>O as material gas (the composition ratio of the silicon oxynitride film: Si=32%, O=59%, N=7%, H=2%). The silicon oxynitride film has a thickness of 100 nm (preferably 50 to 200 nm) and is laid on the lower layer to form a laminate. Without exposing the laminate to the air, a semiconductor film having an amorphous structure (here, an amorphous silicon film) is formed on the laminate by plasma CVD at a temperature of 300° C. using SiH<sub>4</sub> as material gas. The semiconductor film (an amorphous silicon film is used here) is 54 nm (preferably 25 to 200 nm) in thickness.

A base insulating film in this example has a two-layer structure. However, the base insulating film may be a single layer or more than two layers of insulating films mainly containing silicon. The material of the semiconductor film is not limited but it is preferable to form the semiconductor film from silicon or a silicon germanium alloy (Si<sub>1-x</sub>Ge<sub>x</sub> (X=0.0001 to 0.02)) by a known method (sputtering, LPCVD, plasma CVD, or the like). Plasma CVD apparatus used may be one that processes wafer by wafer or one that processes in batch. The base insulating film and the semiconductor film may be formed in succession in the same chamber to avoid contact with the air.

The surface of the semiconductor film having an amorphous structure is washed and then a very thin oxide film, about 2 nm in thickness, is formed on the surface using ozone water. Next, the semiconductor film is doped with a minute amount of impurity element (boron or phosphorus) in order to control the threshold of the TFTs. Here, the amorphous silicon film is doped with boron by ion doping in which diborane (B<sub>2</sub>H<sub>6</sub>) is excited by plasma without mass separation. The doping conditions include setting the acceleration voltage to

25

15 kV, the flow rate of gas obtained by diluting diborane to 1% with hydrogen to 30 sccm, and the dosage to  $2 \times 10^{12}$  atoms/cm<sup>2</sup>.

Next, a nickel acetate solution containing 10 ppm of nickel by weight is applied by a spinner. Instead of application, nickel element may be sprayed onto the entire surface by sputtering.

The semiconductor film is subjected to heat treatment to crystallize it and obtain a semiconductor film having a crystal structure. The heat treatment is achieved in an electric furnace or by irradiation of intense light. When heat treatment in an electric furnace is employed, the temperature is set to 500 to 650° C. and the treatment lasts for 4 to 24 hours. Here, a silicon film having a crystal structure is obtained by heat treatment for crystallization (at 550° C. for 4 hours) after heat treatment for dehydrogenation (at 500° C. for an hour). Although the semiconductor film is crystallized here by heat treatment using an electric furnace, it may be crystallized by a lamp annealing apparatus capable of achieving crystallization in a short time. After an oxide film on the surface of the silicon film having a crystal structure is removed by diluted fluoric acid or the like, a continuous oscillating solid-state laser and the second to fourth harmonic of the fundamental wave are employed in order to obtain crystals of large grain size when crystallizing an amorphous semiconductor film. Since the laser light irradiation is conducted in the air or in an oxygen atmosphere, an oxide film is formed on the surface as a result. Typically, the second harmonic (532 nm) or third harmonic (355 nm) of a Nd:YVO<sub>4</sub> laser (fundamental wave: 1064 nm) is employed. When using a continuous wave laser, laser light emitted from a 10 W power continuous wave YVO<sub>4</sub> laser is converted into harmonic by a non-linear optical element. Alternatively, the harmonic is obtained by putting a YVO<sub>4</sub> crystal and a non-linear optical element in a resonator. The harmonic is preferably shaped into oblong or elliptical laser light on an irradiation surface by an optical system and then irradiates an irradiation object. The energy density required at this point is about 0.01 to 100 MW/cm<sup>2</sup> (preferably 0.1 to 10 MW/cm<sup>2</sup>). During the irradiation, the semiconductor film is moved relative to the laser light at a rate of 10 to 2000 cm/s. Of course, although a TFT can be formed by using the silicon film having a crystalline structure before the second harmonics of the continuous oscillating YVO<sub>4</sub> laser is irradiated thereon, it is preferable that the silicon film having a crystalline structure after the laser light is irradiated thereon is used to form the TFT since the silicon film irradiated the laser light thereon has an improved crystallinity and electric characteristics of TFT are improved. For instance, although, when TFT is formed by using the silicon film having a crystalline structure before the laser light is irradiated thereon, a mobility is almost 300 cm<sup>2</sup>/Vs, when TFT is formed by using the silicon film having a crystalline structure after the laser light is irradiated thereon, the mobility is extremely improved with about 500 to 600 cm<sup>2</sup>/Vs. After the crystallization is conducted using nickel as a metal element that promotes crystallization of silicon, the continuous oscillating YVO<sub>4</sub> laser is irradiated thereon though, not limited thereof, after the silicon film is formed having an amorphous structure and the heat treatment is performed for dehydrogenation, and the silicon film having a crystalline structure may be obtained by the second harmonics of the continuous oscillating YVO<sub>4</sub> laser is irradiated.

The pulse oscillation laser may be used for as a substitute for the continuous oscillating laser. In the case that the excimer laser of the pulse oscillation is used, it is preferable that the frequency is set to 300 Hz, and the laser energy density is

26

set from 100 to 1000 mJ/cm<sup>2</sup> (typically 200 to 800 mJ/cm<sup>2</sup>). Here, the laser light may be overlapped 50 to 98%.

In addition to the oxide film formed by the laser light irradiation, a barrier layer composed of an oxide film, which treated with ozone water for 120 seconds having 1 to 5 nm in total, is formed. The barrier layer here is formed using ozone water in this example but it may be formed by oxidizing the surface of the semiconductor film having a crystal structure through ultraviolet irradiation in an oxygen atmosphere, or formed by oxidizing the surface of the semiconductor film having a crystal structure through oxygen plasma treatment, or by using plasma CVD, sputtering or evaporation to form an about 1 to 10 nm thick oxide film. The oxide film formed by the laser light irradiation may be removed before the barrier layer is formed.

Next, an amorphous silicon film containing argon is formed on the barrier layer by plasma CVD or sputtering to serve as a gettering site. The thickness of the amorphous silicon film is 50 to 400 nm, here 150 nm. The amorphous silicon film is formed in an argon atmosphere with the film formation pressure to 0.3 Pa by sputtering using the silicon target.

Thereafter, heat treatment is conducted in an electric furnace at 650° C. for 3 minutes for gettering to reduce the nickel concentration in the semiconductor film having a crystal structure. Lamp annealing apparatus may be used instead of an electric furnace. Using the barrier layer as an etching stopper, the gettering site, namely, the amorphous silicon film containing argon elements is selectively removed. Then, the barrier layer is selectively removed by diluted fluoric acid. Nickel tends to move toward a region having high oxygen concentration during gettering, and therefore it is desirable to remove the barrier layer that is an oxide film after gettering.

Next, a thin oxide film is formed on the surface of the obtained silicon film containing a crystal structure (also referred to as a polysilicon film) using ozone water. A resist mask is then formed and the silicon film is etched to form island-like semiconductor layers separated from one another and having desired shapes. After the semiconductor layers are formed, the resist mask is removed.

The oxide film is removed by an etchant containing fluoric acid, and at the same time, the surface of the silicon film is washed. Then, an insulating film mainly containing silicon is formed to serve as a gate insulating film **803**. The gate insulating film here is a silicon oxynitride film (composition ratio: Si=32%, O=59%, N=7%, H=2%) formed by plasma CVD to have a thickness of 115 nm.

Next, a laminate of a first conductive film with a thickness of 20 to 100 nm and a second conductive film with a thickness of 100 to 400 nm is formed on the gate insulating film. In this example, a tantalum nitride film with a thickness of 50 nm is formed on the gate insulating film **803** and then a tungsten film with a thickness of 370 nm is laid thereon. The conductive films are patterned by the procedure shown below to form gate electrodes and wirings.

The conductive materials of the first conductive film and the second conductive film are formed by using elements selected from the group consisting of Ta, W, Ti, Mo, Al, and Cu, or alloys or compounds mainly containing the above elements. The first conductive film and the second conductive film may be semiconductor films, typically polycrystalline silicon films, doped with phosphorus or other impurity elements or may be Ag—Pd—Cu alloy films. The present invention is not limited to a two-layer structure conductive film. For example, a three-layer structure consisting of a 50 nm thick tungsten film, 500 nm thick aluminum-silicon alloy (Al—Si) film, and 30 nm thick titanium nitride film layered in this

order may be employed. When the three-layer structure is employed, tungsten of the first conductive film may be replaced by tungsten nitride, the aluminum-silicon alloy (Al—Si) film of the second conductive film may be replaced by an aluminum-titanium alloy (Al—Ti) film, and the titanium nitride film of the third conductive film may be replaced by a titanium film. Alternatively, a single-layer conductive film may be used.

ICP (inductively coupled plasma) etching is preferred for etching of the first conductive film and second conductive film (first etching treatment and second etching treatment). By using ICP etching and adjusting etching conditions (the amount of electric power applied to a coiled electrode, the amount of electric power applied to a substrate side electrode, the temperature of the substrate side electrode, and the like), the films can be etched and tapered as desired. The first etching treatment is conducted after a mask made of resist is formed. The first etching conditions include applying an RF (13.56 MHz) power of 700 W to a coiled electrode at a pressure of 1 Pa, employing  $\text{CF}_4$ ,  $\text{Cl}_2$ , and  $\text{O}_2$  as etching gas, and setting the gas flow rate ratio thereof to 25:25:10 (sccm). The substrate side (sample stage) also receives an RF (13.56 MHz) power of 150 W to apply a substantially negative self-bias voltage. The area (size) of the substrate side electrode is 12.5 cm×12.5 cm and the coiled electrode is a disc 25 cm in diameter (here, a quartz disc on which the coil is provided). The W film is etched under these first etching conditions to taper it around the edges. Thereafter, the first etching conditions are switched to the second etching conditions without removing the mask made from resist. The second etching conditions include using  $\text{CF}_4$  and  $\text{Cl}_2$  as etching gas, setting the gas flow rate ratio thereof to 30:30 (sccm), and giving an RF (13.56 MHz) power of 500 W to a coiled electrode at a pressure of 1 Pa to generate plasma for etching for about 30 seconds. The substrate side (sample stage) also receives an RF power of 20 W (13.56 MHz) to apply a substantially negative self-bias voltage. Under the second etching conditions where a mixture of  $\text{CF}_4$  and  $\text{Cl}_2$  is used, the W film and the TaN film are etched to almost the same degree. The first etching conditions and the second etching conditions constitute the first etching treatment.

Next follows the second etching treatment with the resist mask kept in place. The third etching conditions include using  $\text{CF}_4$  and  $\text{Cl}_2$  as etching gas, setting the gas flow rate ratio thereof to 30:30 (sccm), and giving an RF (13.56 MHz) power of 500 W to a coiled electrode at a pressure of 1 Pa to generate plasma for etching for 60 seconds. The substrate side (sample stage) also receives an RF power of 20 W (13.56 MHz) to apply a substantially negative self-bias voltage. Then, the third etching conditions are switched to the fourth etching conditions without removing the resist mask. The fourth etching conditions include using  $\text{CF}_4$ ,  $\text{Cl}_2$ , and  $\text{O}_2$  as etching gas, setting the gas flow rate ratio thereof to 20:20:20 (sccm), and giving an RF (13.56 MHz) power of 500 W to a coiled electrode at a pressure of 1 Pa to generate plasma for etching for about 20 seconds. The substrate side (sample stage) also receives an RF power of 20 W (13.56 MHz) to apply a substantially negative self-bias voltage. The third etching conditions and the fourth etching conditions constitute the second etching treatment. At this stage, gate electrodes **804** having a first conductive layer **804a** as the lower layer and a second conductive layer **804b** as the upper layer, and wirings **805** to **807** are formed.

Next, the mask made of resist is removed for the first doping treatment to dope with the entire surface using the gate electrodes **804** to **807** as masks. The first doping treatment employs ion doping or ion implantation. Here, ion doping

conditions are that the dosage is set to  $1.5 \times 10^{14}$  atoms/cm<sup>2</sup>, and the acceleration voltage is set from 60 to 100 kV. As an impurity element that imparts the n-type conductivity, phosphorus (P) or arsenic (As) is typically used. First impurity regions (n<sup>−</sup> regions) **822** to **825** are formed in a self-aligning manner.

Masks made from resist are newly formed. At this moment, since the off current value of the switching TFT **903** is lowered, the masks are formed to overlap the channel formation region of a semiconductor layer forming the switching TFT **903** of the pixel portion **901**, and a portion thereof. The masks are formed to protect the channel formation region of the semiconductor layer forming the p-channel TFT **906** of the driver circuit and the periphery thereof. In addition, the masks are formed to overlap the channel formation region of the semiconductor layer forming the current control TFT **904** of the pixel portion **901** and the periphery thereof.

An impurity region (n<sup>−</sup> region) that overlaps with a portion of the gate electrode is formed by conducting selectively the second doping treatment using the masks made of resist. The second doping treatment employs ion doping or ion implantation. Here, ion doping is used, the flow rate of gas obtained by diluting phosphine ( $\text{PH}_3$ ) with hydrogen to 5% is set to 30 sccm, the dose is set to  $1.5 \times 10^{14}$  atoms/cm<sup>2</sup>, and the acceleration voltage is set to 90 kV. In this case the masks made from resist and the second conductive layer serve as masks against the impurity element that imparts the n-type conductivity and second impurity regions **811** and **812** are formed. The second impurity regions are doped with the impurity element that imparts the n-type conductivity in a concentration range of  $1 \times 10^{16}$  to  $1 \times 10^{17}$  atoms/cm<sup>3</sup>. Here, the same concentration range as the second impurity region is referred to as an n<sup>−</sup> region.

Third doping treatment is conducted without removing the masks made from resist. The third doping treatment employs ion doping or ion implantation. As impurity elements imparts n-type conductivity, phosphorus (P) or arsenic (As) are used typically. Here, ion doping is used, the flow rate of gas obtained by diluting phosphine ( $\text{PH}_3$ ) with hydrogen to 5% is set to 40 sccm, the dosage is set to  $2 \times 10^{15}$  atoms/cm<sup>2</sup>, and the acceleration voltage is set to 80 kV. In this case the masks made from resist, the first conductive layer and the second conductive layer serve as masks against the impurity element that imparts the n-type conductivity and third impurity regions **813**, **814**, **826** to **828** are formed. The third impurity regions are doped with the impurity element that imparts the n-type conductivity in a concentration range of  $1 \times 10^{20}$  to  $1 \times 10^{21}$  atoms/cm<sup>3</sup>. Here, the same concentration range as the third impurity region is referred to as an n<sup>+</sup> region. After removing the resist mask and the new resist mask is formed, the fourth doping treatment is conducted. The fourth impurity regions **818**, **819**, **832**, **833** and the fifth impurity regions **816**, **817**, **830**, **831** are formed in which impurity elements imparts p-type conductivity are added to the semiconductor layer forming the p-channel TFT by the fourth doping treatment.

The concentration of the impurity element that imparts the p-type conductivity is set from  $1 \times 10^{20}$  to  $1 \times 10^{21}$  atoms/cm<sup>3</sup> to add to the fourth impurity regions **818**, **819**, **832**, and **833**. The fourth impurity regions **818**, **819**, **832**, and **833** being regions (n<sup>−</sup> regions) are already doped with phosphorus (P) in the previous step but are doped with the impurity element that imparts the p-type conductivity in a concentration 1.5 to 3 times the phosphorus concentration to obtain the p-type conductivity. Here, a region having the same concentration range as the fourth impurity regions is also called a p<sup>+</sup> region.

The fifth impurity regions **816**, **817**, **830**, and **831** are formed in the region overlaps with the taper portion of the

second conductive layer. The impurity elements imparts p-type conductivity is added thereto at the concentration range from  $1 \times 10^{18}$  to  $1 \times 10^{20}$  atoms/cm<sup>3</sup>.

Here, the region having the same concentration range as the fifth impurity regions is referred to as a p<sup>+</sup> region.

Through the above steps, an impurity region having the n-type or p-type conductivity is formed in each semiconductor layer. The conductive layers **804** to **807** become the gate electrodes of TFTs.

An insulating is formed to cover almost the entire surface (not shown). In this example, the silicon oxide film having 50 nm in thickness is formed by plasma CVD method. Of course, the insulating film is not limited to a silicon oxide film and a single layer or laminate of other insulating films containing silicon may be used.

The next step is activation treatment of the impurity elements used to dope the respective semiconductor layers. The activation step employs rapid thermal annealing (RTA) using a lamp light source, irradiation of a laser, heat treatment using a furnace, or a combination of these methods.

This example shows an example that the insulating film is formed before the above-described activation. However, the insulating film may be formed after the activation.

The first interlayer insulating film **808** made from a silicon nitride film is formed. Then, the semiconductor layers are subjected to heat treatment (at 300 to 550° C. for 1 to 12 hours) to hydrogenate the semiconductor layers. This step is for terminating dangling bonds in the semiconductor layers using hydrogen contained in the first interlayer insulating film **808**. The semiconductor layers can be hydrogenated irrespective of the presence of the insulating film made from a silicon oxide film (not shown in a figure). Other hydrogenation methods employable include plasma hydrogenation (using hydrogen excited by plasma).

Next, a second interlayer insulating film **809a** is formed on the first interlayer insulating film **808** from an organic insulating material or an inorganic insulating material. In this example, an acrylic resin film **809a** is formed to have a thickness of 1.6 μm.

Formed next are contact holes reaching the conductive layers that serve as the gate electrodes or gate wires and contact holes reaching the respective impurity regions. In this example, etching treatment is conducted several times in succession. Also, in this example, the first interlayer insulating film is used as an etching stopper to etch the second interlayer insulating film, and then the first interlayer insulating film is etched. Thereafter, electrodes **835** to **841**, specifically, a source wiring, a power supply line, a lead-out electrode, a connection electrode, etc. are formed from Al, Ti, Mo, W, etc. Here, the electrodes and wirings are obtained by patterning a laminate of a Ti film (100 nm in thickness), an Al film containing silicon (350 nm in thickness), and another Ti film (50 nm in thickness). The source electrode, the source wiring, the connection electrode, the lead-out electrode, the power supply line, and the like are thus formed as needed. A lead-out electrode for the contact with a gate wiring covered with an interlayer insulating film is provided at an end of the gate wiring, and other wirings also have at their ends input/output terminal portions having a plurality of electrodes for connecting to external circuits and external power supplies.

A driver circuit **902** having a CMOS circuit in which an n-channel TFT **905** and a p-channel TFT **906** are combined complementarily and a pixel portion **901** with a plurality of pixels each having an n-channel TFT **903** or a p-channel TFT **904** are formed in the manner described above.

Next, a third interlayer insulating film **809b** made from an inorganic insulating material is formed on the second inter-

layer insulating film **809a**. The silicon nitride film **809b** with a thickness of 200 nm is formed by sputtering here. Alternatively, the silicon nitride film **809b** may contain hydrogen, which is included in a reaction gas.

Next, the third interlayer insulating film **809b** is etched, and then a contact hole is formed so as to reach the connection electrode **841** formed in contact with the drain region of the current control TFT **904** made from a p-channel TFT. A pixel electrode **834** is formed so as to contact and overlap with the connection electrode **841**. In this example, the pixel electrode **834** is made from a material having a large work function, specifically, such as platinum (Pt), chrome (Cr), tungsten (W) and nickel (Ni) with a thickness of 0.1 to 1 μm in order to make the pixel electrode **834** function as an anode of an organic light emitting element.

An inorganic insulator **842** is formed on each end of the pixel electrode **834** so as to cover the each end of the pixel electrode **834**. It is preferable that the inorganic insulator **842** is formed from an insulating film containing silicon by sputtering and then patterned. In addition to that, the inorganic insulator **842** may contain hydrogen which is included in the reaction gas. Further, a bank formed from an organic insulator may be formed for as a substitute for the inorganic insulator **842**.

Next, an EL layer **843** and the cathode **844** of the organic light emitting element are formed on the pixel electrode **834** whose ends are covered by the inorganic insulator **842**. In this example, the EL layer **843** may be formed by ink jet method, evaporation, spin coating method and the like.

An EL layer **843** (a layer for light emission and for moving of carriers to cause light emission) may be formed by freely combining a light emitting layer, an electric charge transporting layer and an electric charge injection layer. For example, a low molecular weight organic EL material or a high molecular weight organic EL material is used to form an EL layer. An EL layer may be a thin film formed of a light emitting material that emits light by singlet excitation (fluorescence) (a singlet compound) or a thin film formed of a light emitting material that emits light by triplet excitation (phosphorescence) (a triplet compound). Inorganic materials such as silicon carbide may be used for the electric charge transporting layers and electric charge injection layers. Known organic EL materials and inorganic materials can be employed.

Moreover, it is considered to be preferable that as a material used for a cathode **844**, a metal whose work function is small (representatively, metal elements belonging to 1 Group or 2 Group of the periodic table) and an alloy containing these are used. Since the smaller the work function is, the more the light emitting efficiency is enhanced, it is preferable that among these, as a material used for a cathode, an alloy such as MgAg, MgIn or AlLi or after the film that has been formed with elements belonging to Group 1 or Group 2 of the periodic table by co-vapor deposition or the like was formed in a thin film, it is made a laminated layer structure in which a transparent conductive film (ITO (indium tin oxide alloy), indium oxide-zinc oxide alloy (In<sub>2</sub>O<sub>3</sub>—ZnO), zinc oxide (ZnO) and the like) has been formed.

Subsequently, a protective film **846** for covering the cathode **844** is formed. For the protective film **846**, an insulating film whose major component is silicon nitride or silicon oxynitride may be formed by a sputtering method, as shown in Embodiment 2, for the purpose that the drawback in the EL layer is terminated with hydrogen, it is preferable that a film **845** containing hydrogen is provided on the cathode **844**.

As the film **845** containing hydrogen, an insulating film whose major component is carbon or silicon nitride may be formed by a PCVD method, upon the formation of the film,



31

the drawback in the organic compound layer can be terminated with hydrogen which has been made plasmatic. Moreover, the drawback in the organic compound layer can be terminated with hydrogen by diffusing hydrogen from the above-described film containing hydrogen by means of performing the heating treatment in the temperature range where the organic compound layer is durable and by means of utilizing the heat generation generated at the time when the light emitting element emits the light.

Moreover, the protective film **846** and the film **845** containing hydrogen prevent the materials for promoting the deterioration caused by the oxidization of the EL layer, that is, moisture, oxygen and the like from invading from the exterior. However, the protective film, the film containing hydrogen and the like may not be provided in the input and output terminal section necessary to be connected to FPC later.

The stage where the steps so far were terminated is shown in FIG. **12**. It should be noted that in FIG. **12**, a switching TFT **903** and a TFT for supplying the current to an organic light emitting element (TFT for controlling current **904**) are shown, however a variety of circuits consisting of a plurality of TFTs and the like may be provided beyond the gate electrode of the relevant TFT. Needless to say, it is not particularly limited.

Subsequently, it is preferable that the organic light emitting element is completely interrupted by encapsulating the organic light emitting element having at least a cathode, an organic compound layer and an anode with a sealing substrate or a sealing can, thereby preventing the materials such as moisture, oxygen and the like promoting the deterioration caused by the oxidization of the EL layer from invading from the exterior. It is preferable that the degassing is carried out by performing the annealing under the vacuum immediately before it is encapsulated with the sealing substrate or the sealing can. Moreover, it is preferable that at the time when the sealing substrate is pasted, it is performed under the atmosphere containing hydrogen and an inert gas (rare gas or nitrogen) and hydrogen is contained in the space sealed with sealing. The drawback in the organic compound layer can be terminated with hydrogen by diffusing hydrogen from the above-described space containing hydrogen by means of utilizing the heat generation generated at the time when the light emitting element emits the light. Terminating the drawback in the organic compound layer with hydrogen, the reliability for a light emitting device is enhanced.

Subsequently, a FPC (flexible print circuit) is pasted on the respective electrodes of the input and output terminal section with an anisotropic conductive material. An anisotropic conductive material is composed of a resin and a conductive particle having a diameter of several tens to several hundreds  $\mu\text{m}$  whose surface has been plated with Au or the like, and the respective electrodes of the input and output terminal section and the wirings formed in the FPC are electrically connected each other with the conductive particle.

Moreover, color filters corresponding to the respective pixels are provided on the sealing substrate. The circularly polarized plate is not needed by providing the color filters. Furthermore, if it is necessary, the other optical film may be provided. Moreover, IC chip or the like may be mounted.

Moreover, using the fabrication unit shown in FIG. **6** or FIG. **7**, according to Embodiment 4, a light emitting device can be prepared with an excellent throughput.

A module type light emitting device to which a FPC has been connected is completed by the above-described steps.

Moreover, the present Example can be freely combined with Embodiment 1, Embodiment 2, Embodiment 3, Embodiment 4 or Embodiment 5.

32

## Example 2

Example 1 was an example in which a cathode is made transparent conductive film, the emission is taken out in the direction of the arrow shown in FIG. **4A** or FIG. **4B**. However, the configuration (FIG. **4C**) in which the emission is performed in the contrary direction to the direction shown in FIG. **4A** or FIG. **4B** may be also available. In the present Example, the configuration in which the light is emitted in the direction contrary to that of Example 1 is shown. However, since these are approximately the same with each other except that the material of the anode and the material of the cathode are different, here the description in detail is omitted.

In the present Example, as an anode, a transparent conductive film (ITO (indium tin oxide alloy), indium oxide-zinc oxide alloy ( $\text{In}_2\text{O}_3\text{—ZnO}$ ), zinc oxide (ZnO) and the like) is used.

Moreover, as a cathode, an alloy film having the film thickness of 80 nm-200 nm, representatively, an alloy such as MgAg, MgIn, AlLi and the like or a film formed with elements belonging to Group 1 or Group 2 of the periodic table and aluminum by a co-vapor deposition method is used.

In this way, the emission can be made in the direction of the arrow shown in FIG. **4C**.

The present Example is the same with Example 1 except for the above-described points.

Moreover, using the fabrication unit shown in FIG. **6** or FIG. **7** similar to Example 1, according to Embodiment 4, a light emitting device can be prepared with an excellent throughput.

Moreover, in Example 1, by making an pixel electrode cathode, an organic compound layer and an anode are laminated, and the emission may be made in the reverse direction to that of Example 1. In this case, it is desired that a TFT connected to the pixel electrode is made n-channel type TFT.

Moreover, the present Example can be freely combined with Embodiment 1, Embodiment 2, Embodiment 3, Embodiment 4, Embodiment 5 or Example 1.

## Example 3

By implementing the present invention, EL modules (active matrix EL module and passive EC module) can be completed. Namely, by implementing the present invention, all of the electronic equipments into which the various modules are built are completed. Following can be given as such electronic equipment: video cameras; digital cameras; head mounted displays (goggle type displays); car navigation systems; car stereos; personal computers; portable information terminals (mobile computers, mobile phones, electronic books etc.) etc. Examples of these are shown in FIGS. **13A** to **13F** and **14A** to **14C**.

FIG. **13A** is a personal computer which comprises: a main body **2001**; an image input section **2002**; a display section **2003**; and a keyboard **2004** etc.

FIG. **13B** is a video camera which comprises: a main body **2101**; a display section **2102**; a voice input section **2103**; operation switches **2104**; a battery **2105** and an image receiving section **2106** etc.

FIG. **13C** is a mobile computer which comprises: a main body **2201**; a camera section **2202**; an image receiving section **2203**; operation switches **2204** and a display section **2205** etc.

FIG. **13D** is a goggle type display which comprises: a main body **2301**; a display section **2302**; and an arm section **2303** etc.

FIG. **13E** is a player using a recording medium in which a program is recorded (hereinafter referred to as a recording

33

medium) which comprises: a main body **2401**; a display section **2402**; a speaker section **2403**; a recording medium **2404**; and operation switches **2405** etc. This apparatus uses DVD (digital versatile disc), CD, etc. for the recording medium, and can perform music appreciation, film appreciation, games and use for Internet.

FIG. 13F is a digital camera which comprises: a main body **2501**; a display section **2502**; a view finder **2503**; operation switches **2504**; and an image receiving section (not shown in the figure) etc.

FIG. 14A is a mobile phone which comprises: a main body **2901**; a voice output section **2902**; a voice input section **2903**; a display portion **2904**; operation switches **2905**; an antenna **2906**; and an image input section (CCD, image sensor, etc.) **2907** etc.

FIG. 14B is a portable book (electronic book) which comprises: a main body **3001**; display portions **3002** and **3003**; a recording medium **3004**; operation switches **3005** and an antenna **3006** etc. FIG. 14C is a display which comprises: a main body **3101**; a supporting section **3102**; and a display portion **3103** etc.

In addition, the display shown in FIG. 14C has small and medium-sized or large-sized screen, for example a size of 5 to 20 inches. Further, to manufacture the display part with such sizes, it is preferable to mass-produce by executing a multiple pattern using a substrate sized 1×1 m.

As described above, the applicable range of the present invention is extremely large, and the invention can be applied to the electronic equipment of various areas. Note that the electronic devices of this example can be achieved by utilizing any combination of constitutions in Embodiments 1 to 5 and Examples 1 to 2. According to the present invention, since the drawback in an organic compound layer can be terminated with hydrogen, the reliability and the brightness of a light emitting device are enhanced. Moreover, according to the present invention, since a very expensive circularly polarized film can be made unnecessary, the reduction of the manufacturing cost can be realized.

Moreover, according to the present invention, without being dependent upon the film formation method and deposition precision of an organic compound layer, a high definition, a high aperture ratio and a high reliability can be realized for a flat panel display of full colors using the emission colors of red, green and blue.

What is claimed is:

1. A light emitting device comprising:

a first substrate;

a transistor comprising a gate electrode over the first substrate;

a first insulating layer over the transistor;

a first electrode over the first insulating layer, the first electrode being electrically connected to the transistor;

a second insulating layer over the first electrode;

a first organic compound layer over the first electrode and the second insulating layer, the first organic compound layer being electrically connected the first electrode;

a second organic compound layer over the second insulating layer;

a second electrode over the first organic compound layer and the second organic compound layer;

a third electrode comprising the same material as the gate electrode; and

a second substrate over the second electrode,

wherein the first organic compound layer partly overlaps with the second organic compound layer, and

wherein the second electrode is electrically connected to the third electrode.

34

2. The light emitting device according to claim 1, further comprising a silicon nitride layer over and in direct contact with the second electrode.

3. The light emitting device according to claim 1, wherein the second insulating layer comprises an organic resin.

4. The light emitting device according to claim 1, wherein the first insulating layer comprises a material selected from silicon nitride and an acrylic resin.

5. The light emitting device according to claim 1, wherein a space is provided between the first substrate and the second substrate.

6. A display module comprising the light emitting device according to claim 1 and an FPC.

7. An electronic apparatus comprising the light emitting device according to claim 1 and at least one of an antenna, a battery, and an operation switch.

8. A light emitting device comprising:

a first substrate;

a transistor comprising a gate electrode over the first substrate;

a first insulating layer over the transistor;

a first electrode over the first insulating layer, the first electrode being electrically connected to the transistor;

a second insulating layer over the first electrode;

a first organic compound layer over the first electrode and the second insulating layer, the first organic compound layer being electrically connected the first electrode;

a second organic compound layer over the second insulating layer;

a first color filter over the first organic compound layer;

a second color filter over the second organic compound layer;

a shielding section between the first color filter and the second color filter;

a second electrode over the first organic compound layer and the second organic compound layer;

a third electrode comprising the same material as the gate electrode; and

a second substrate over the second electrode,

wherein the shielding section is provided over the first electrode,

wherein the first organic compound layer partly overlaps with the second organic compound layer, and

wherein the second electrode is electrically connected to the third electrode.

9. The light emitting device according to claim 8, further comprising a silicon nitride layer over and in direct contact with the second electrode.

10. The light emitting device according to claim 8, wherein the second insulating layer comprises an organic resin.

11. The light emitting device according to claim 8, wherein the first insulating layer comprises a material selected from silicon nitride and an acrylic resin.

12. The light emitting device according to claim 8, wherein a space is provided between the first substrate and the second substrate.

13. A display module comprising the light emitting device according to claim 8 and an FPC.

14. An electronic apparatus comprising the light emitting device according to claim 8 and at least one of an antenna, a battery, and an operation switch.

15. A light emitting device comprising:

a first substrate;

a transistor comprising a gate electrode over the first substrate;

a first insulating layer over the transistor;

**35**

a first electrode over the first insulating layer, the first electrode being electrically connected to the transistor;  
 a second insulating layer over the first electrode;  
 a first organic compound layer over the first electrode and the second insulating layer, the first organic compound layer being electrically connected the first electrode;  
 a second organic compound layer over the second insulating layer;  
 a second electrode over the first organic compound layer and the second organic compound layer;  
 a third electrode comprising the same material as the gate electrode;  
 a second substrate over the second electrode; and  
 a sealing member between the first substrate and the second substrate;  
 wherein the sealing member is provided over the third electrode,  
 wherein the first organic compound layer partly overlaps with the second organic compound layer, and

**36**

wherein the second electrode is electrically connected to the third electrode.

**16.** The light emitting device according to claim **15**, further comprising a silicon nitride layer over and in direct contact with the second electrode.

**17.** The light emitting device according to claim **15**, wherein the second insulating layer comprises an organic resin.

**18.** The light emitting device according to claim **15**, wherein the first insulating layer comprises a material selected from silicon nitride and an acrylic resin.

**19.** The light emitting device according to claim **15**, wherein a space is provided between the first substrate and the second substrate.

**20.** A display module comprising the light emitting device according to claim **15** and an FPC.

**21.** An electronic apparatus comprising the light emitting device according to claim **15** and at least one of an antenna, a battery, and an operation switch.

\* \* \* \* \*